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ABSTRACT

Increased human population has led to more frequent interactions with the environment. The results of those interactions have affected the Earth's ecosystem. This manual contains hands-on, problem-centered activities to help students develop an environmental ethic and stewardship regarding waste management. The activities are grouped under three thematic headings: where wastes end up, options and choices we have involving waste management, and the interconnectedness of environmental issues. The introduction provides the theoretical foundation and principles of learning for the environmental education activities and a rationale for reducing, reusing, and recycling. Part 1 contains 18 activities on the problem of solid waste, alternatives to incineration and landfilling, and developing a school reduction, reuse, and recycling program. Part 2 contains 12 activities related to waste minimization, composting, hazardous wastes, recycling, product packaging, energy consumption, and consumer decision-making. Part 3 contains 12 activities concerning the additional environmental issues of population growth, ecosystems, finite natural resources, lifecycle analysis, air pollution, acid rain, wastewater treatment, environmental careers, ozone depletion, human resources, and land use. Each activity contains the activities' objectives, recommended instructional method, background information, materials needed, teaching procedures, and ideas for further study. Contains a glossary of 67 terms. (MDH)

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# CLOSING THE LOOP: INTEGRATED WASTE MANAGEMENT ACTIVITIES FOR SCHOOL & HOME

K-12

**Institute for Environmental Education**
**18554 Haskins Road**
**Chagrin Falls, Ohio 44023-1823**
**Tel: 216/543-7303; Fax: 216/543-7160**

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## *A SCHOOL-BASED WASTE MINIMIZATION AND EDUCATION PROGRAM*

# CLOSING THE LOOP: INTEGRATED WASTE MANAGEMENT ACTIVITIES FOR SCHOOL AND HOME

## K-12 EDITION

The Institute for Environmental Education
18554 Haskins Road
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Tel: 216/543-7303; FAX: 216/543-7160
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*The Nature Conservancy Student Stewardship Program Student's Manual*

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Using a bicycle, this activity examines "by-products" and hazardous waste produced in the manufacture, use, and disposal of products we buy. The process introduces students to raw materials, their manufactured forms, and the issues surrounding their appropriate recycling, reuse, and disposal.

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This activity asks students to inventory their home's hazardous wastes and, based on the class' combined inventory and demographics, calculate the amount of hazardous waste in the community. Study sheets include descriptions of hazardous materials, their uses and dangers, and safer alternatives.

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**How to Calculate BTUs Per Container** II-9

Through calculations based on energy requirements for manufacture, students will compare the energy used for packaging a food product with the actual energy in the food itself and calculate the energy savings possible through purchasing choices, recycling, & reuse.

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Population and food supply are explored using a simple mathematical model. Presented with a worksheet and a hypothetical case history, students are asked to calculate the point at which population will outstrip resource availability. Students are invited to design their own models to learn how change in variables, large and small, can affect local outcomes.

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Using live animals and food-tasting, students learn that "different" from what they know doesn't mean "bad," "dangerous," or "ugly." The activity introduces the concepts of humans beings as Earth "housemates" with all creatures and of value in learning all we can about diversity -- in animals, in foods, in lifestyles, in culture, as a means of taking care of our common environment.

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Based on the premise that great social issues have been treated for centuries in theater, this activity addresses waste as the issue and presents students with an introductory set of characters, a plot, a setting, and invites them to write the script for a play which they will cast, produce, and direct.

**Lifecycle Analysis** III-5

This activity addresses the issue of green consumerism and environmental labeling. In particular, it examines the complex issue of determining the environmental cost of a product. Students are asked to draw up criteria for their own environmental seal of approval, "EcoStamp." Calculation worksheets are included for students to compute costs.

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Students sample air contamination levels using simple, hand-made collection devices to discover the magnitude of airborne solid waste. In addition to introducing students to the concept that solid waste is not simply a problem of litter and landfills, the activity invites students to assess the merits and flaws of various sampling techniques and come up with variables and controls for sampling studies.

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An activity that introduces students of all ages to environmental careers and the skill requirements for them. Students and teachers are referred to a variety of local community resources for both in-school visits and field trips. The activity includes guidelines for teachers to suggest to visitors and field-trip hosts to help them introduce their environmental careers to students in terms that are practical, hands-on, and problem-centered.

**The Ozone Hole Blues** III-10

Just as "Rockin' Recyclables" uses theater as a means for addressing a social problem, this activity invites students to write lyrics and compose music about solid waste and other environmental topics. Offering an original composition as a model and several suggestions for adapting existing tunes to new lyrics, the activity lends itself to in-class and all-school performance pieces.

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## CONTENTS (continued)

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## PART III EVERYTHING IS CONNECTED

- *Other Environmental Issues* (continued)

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The premise of this activity is that humans -- like the prairie grasses, the great whales, are "resources" of this Earth and we must treat them wisely. To that end, the goal of teaching is to make school and learning an affirmation of every child. Using a series of postable statements about learners and the conditions under which learning occurs, this activity challenges students and teachers to share their experiences and feelings as learners in an effort to help both reach their fullest potential.

**Shaping the Land** III-12

Land use, like population, is a topic which by nature makes global issues quite local. This activity uses three different texts (case histories) and a mapping assignment to lead students to investigate how land in their community is used, why it is used as it is, and what choices individuals and communities have in making environmentally informed land-use choices.

**GLOSSARY**

## ACKNOWLEDGEMENTS

*Closing the Loop: Integrated Waste Management Activities for School and Home* is a companion piece to the *Administrator's Manual.* Neither would exist if there hadn't been "A School-based Waste Minimization Program" in the first place. The program came about as the result of nearly two years of planning, designing, and fund-seeking. When the going was tough and there was more work than there was funding, John Brandt, Anne Claire Broughton, and Mary Chadbourne worked on to make sure that the program got off the ground.

Along the way numerous people contributed their advice, guidance, and perspectives on the solid waste problem. In every way, they have helped to shape the process and the content of the school-based plan. We are grateful to them, and continue to call on them as the need arises. In alphabetical order, they are: Virginia Aveni, Environmental Planning Manager, the Cuyahoga County Planning Commission; Rich Benz, Science Teacher, Wickliffe High School; Ernest Benchell, Willoughby Iron and Waste; Bernie Bruder, Avon Lake Water Pollution Control Center and Water Filtration Plant; Ed Butler, Recycling Coordinator, City of Solon; John Demuth, Cuyahoga County Planning Commission; Bill Deighan, John Carroll University; Dan Delong, Cleveland Public Schools; Thomas J. Denbow, Planning and Environmental Systems Division, URS Consultants; William M. Denihan, Service Director, City of Cleveland; Matthias Dobler, University of Hamburg, Germany; Kelly Dodson, Akron Recycling Center; Teresa Donkin, Ohio EPA; Paul Dunford, Science Teacher, Avon Lake Avon Lake City Schools; Bob Eckardt, Program Officer, The Cleveland Foundation; Linda Freeman, Program Coordinator, Greater Cleveland Education Development Center; Jeff Hamill, Plant Procurement Representative, Packaging Corporation of America; Sondra Hardis, former Senior Contributions Associate, BP America; Mike Hill, Instructor of Science, Kirtland Intermediate School; Pat Holland, Solid Waste Program Manager, Cuyahoga County Planning Commission; John Hug, Environmental Education Consultant, Ohio Department of Education; Bob Jaquay, Cuyahoga County Planning Commission; Mike Kalstrom, Cuyahoga County Sanitary Engineer's Office; Ken Killinger, Avon Lake Water Pollution Control Center and Water Filtration Plant; Bob Kobak, A-Kobak Recycling, Inc.; Martha Lant, Public Relations, Lakewood City Schools; Pat Meier, Lake County Extension Service; Carlton Moody, Executive Director, Business and Personnel Management, Shaker Heights Board of Education; Jack Nairus, Assistant Superintendent, Curriculum and Instruction, Cleveland City Schools; Patricia Nash, Consultant, Proffitt & Associates; Tom Norton, President, Turtle Plastics; Fred Ohle, Waste Management, Inc.; George Peters, Education and Research Manager, ODNR; Jim Rieke, Assistant Director, Service Operations, Lakewood City Schools; Claire Rogers, Superintendent, Collinwood Cluster, Cleveland City Schools; Mary Sexton, Sexton & Associates; Ray Smalley, Science Office, Cleveland City Schools; Pat Smith, Waste Options, Inc.; Terry

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There are others who helped us along the way and whose names could constitute another list of the same length. We will stop here, however, and trust they will know we are grateful.

We also want to express our thanks to a number of organizations throughout the country that have given us permission to reproduce or to adapt their materials for our collection of activities. While we have acknowledged each of them in their respective activities, I do want to mention each of them here and their publications from which we have drawn some of the materials that appear in this volume: The Ohio Department of Natural Resources' *Super Saver Investigators*; the Florida Department of Education's *4 Rs Project*; the National Science Teachers Association's *Polymer Chemistry*; and the Washington State Department of Ecology's *A-Way with Waste*. We believe their work will be a valuable asset to teachers who do not know it. We are grateful for their generosity and fine work.

The Institute is also grateful for the financial support of BP America Corporate Contributions, The Cleveland Foundation, and The George Gund Foundation. We couldn't have brought the program to the schools without their help.

Our sincere thanks go to Anne Claire Broughton, Mary Chadbourne, and Ben Hitchings for drafting many of the activities and for serving as the editorial team that also critiqued and adapted, as required, those activities included here from other sources. Their intelligence and devotion to the task was essential. Our thanks also goes to Dan Delong, teacher, Cleveland Public Schools, who helped pilot sample activities in the training workshops in the fall of 1991, and to Dr. Harry Bury, Baldwin-Wallace College, who assisted in team-building activities during the workshops. We also want to thank Caitlin M. Roberts, who did the original illustrations three years ago and who now is a freshman at Maryland Institute, College of Art. Thanks, too, go to Sharon Fidler for helping out on the text entry and to Mary Chadbourne for wrestling the whole business through the desk-top publishing process.

The support of the Institute's Trustees -- Tom Bayless, Don Dalton, John Gabel, Joan Holmes, Baird Tenney, Ron Yarian, and Dr. Harry Bury -- have stood solidly behind this and other efforts over the years. We appreciate their confidence and continued encouragement.

The Institute's Advisory Board members also have contributed valuable guidance for which we are grateful: John Brandt, Tom Denbow, John Gabel, Carrie Kurutz, Michael Kurutz, Linda Johnson, Carlton Moody, Pat Nash, Paul Sears, and Neil Seldman.

We also want to thank you, school district administrators, teachers, staff, and students, for taking on the important work of waste management in school buildings and of environmental education in the classroom. All of us welcome your remarks about how to improve this text for the next edition.

-- Joseph H. Chadbourne
October 1993

# INTRODUCTION

When the world was less crowded, when we were less knowledgeable about how earth, air, water, and we human beings related, the consequences of our actions on the environment were not very clear.

As populations increased, the interactions with the physical environment have become more frequent. With that frequency has come increasing disaster with startling, grave consequences. We humans alone are throwing out of balance the Earth's ecosystem through choices that have led to acid rain; depletion of the ozone layer; the dramatic reduction of the diversity in animal and plant life; children forever impaired by the poison of toxic wastes in their homes and community; the destruction of the great rain forests that are the lungs of the world.

Yet many of us behave as though these problems were remote, not our affair. But all the individual human actions over time add up to problems of global dimension that now touch us all. The consequences of human actions **are** clear, though we may not wish to own up to them. Yet we must take ownership for them -- in the past, in the future -- but most importantly, today. What others did yesterday is what we have today. What we do today is what others will have tomorrow. We cannot afford to have another generation grow up without an environmental ethic, without an attitude of stewardship toward the Earth's resources.

In light of this need to help students link cause and effect, to nurture an environmental ethic and stewardship, we assembled this set of activities. We reviewed waste-related and other environmental education curricula from all over the country and selected the very best to adapt for this collection. We also drew on some standard activities we had produced earlier, and we wrote many new ones. Our aim is to support teachers at all grade levels and in all subjects in using environmental activities in their classes.

We have grouped activities in this manual under three thematic headings:

- Everything ends up somewhere
- We have options and we make choices
- Everything is connected

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We also have used the following criteria for the activities:

- Hands-on
- Problem-centered
- Practical, so that teachers and students can relate the content to school, home, other life situations, both in childhood and adulthood
- Adaptable across grade levels and subjects

We are providing you with some vehicles, some subjects to use in your classroom. But you will finally deliver the intangible, essential part that can't be delivered on paper: a love of and respect for self and learning. These are not grandiose words. They describe not what we've come to but where we've always been. It matters -- it always has -- what we do and how we do it.

Finally, as a teacher you know from experience about the differences among children's learning styles, culture, received ideas, potential. It is important to revisit how and why we all learn and under what conditions learning best occurs. To that end, we have also included our "Principles and Conditions of Learning" (as a text and as an activity), believing that they offer an effective process for teaching environmental education and for supporting the values that serve as standards for environmentally responsible adults.

We invite your evaluation of the activities included here. We depend on your thoughts and experience to guide us in serving the needs of teachers and their students. We are eager to hear from you.

-- Mary M. Chadbourne, Vice President
Institute for Environmental Education
October 1993

# WHAT MAKES EDUCATION "ENVIRONMENTAL"?

If there is a body of knowledge that serves as a basis for education as "environmental," it may be summed up by knowing, understanding, and applying these principles described by Barry Commoner in *The Closing Circle, Alfred A. Knopf, New York, NY, 1971. We quote from pages 33 through 45:**

> ***The First Law of Ecology: Everything Is Connected to Everything Else.*** *It reflects the existence of the elaborate network of interconnections in the ecosphere: among different living organisms, and between populations, species, and individual organisms and their physicochemical surroundings.*
>
> ***The Second Law of Ecology: Everything Must Go Somewhere.*** *This is, of course, simply a somewhat informal restatement of a basic law of physics - that matter is indestructible. Applied to ecology, the law emphasizes that in nature there is no such thing as `waste.' In every natural system, what is excreted by one organism as waste is taken up by another as food.*
>
> ***The Third Law of Ecology: Nature Knows Best.*** *Stated baldly, the third law of ecology holds that any major man-made change in a natural system is likely to be detrimental* to that system.
>
> **The Fourth Law of Ecology: There Is No Such Thing as a Free Lunch.** In ecology, as in economics, the law is intended to warn that every gain is won at some cost. Because the global ecosystem is a connected whole, in which nothing can be gained or lost and which is not subject to over-all improvement, anything extracted from it by human effort must be replaced. Payment of this price cannot be avoided; it can only be delayed.

The challenge to educators who treat environmental matters in their classrooms is to keep these principles foremost in the minds of students as issues, choices, problems, and solutions are addressed. Whether conducting a study of litter on the school grounds or presenting a plan for a recycling program to a school task force, a test of recommendations and solutions should be measured against the principles reflected in Commoner's Four Laws. Educationally, these Laws remind us that none of us acts in isolation and that our choices as children and adults will always have an effect on the rest of the world.

---

*** We have based the three divisions of this activities manual on Commoner's Laws, although we have done some reordering and rewording of them.**

# INSTITUTE FOR ENVIRONMENTAL EDUCATION

# PRINCIPLES & CONDITIONS OF LEARNING

## I. PRINCIPLES OF LEARNING:*

### PRINCIPLE 1

**Learning is an experience which occurs inside the learner and is activated by the learner.** The process of learning is primarily controlled by the learner and not by the teacher (group leader). Changes in perception and behavior are more products of human meaning and perceiving rather than any forces exerted upon the individual. Learning is not only a function of what a teacher does to or says to or provides for a learner. More significantly, learning has to do with something which happens in the unique world of the learner. It flourishes in a situation in which teaching is seen as a facilitating process that assists people to explore and discover the personal meaning of events for them.

**No one directly teaches anyone anything of significance.** If teaching is defined as a process of directly communicating an experience or a fragment of knowledge, then it is clear that little learning occurs as a result of this process and the learning that does take place is usually inconsequential. People learn what they want to learn, they see what they want to see and hear what they want to hear. Learning cannot be imposed. When we impose ideas on people we train them. When we create an atmosphere in which people are free to explore ideas in dialogue and through interaction with other people, we educate them. Very little learning takes place without personal involvement and

---

* Joe Chadbourne designed the Institute's earliest programs at University School, Cleveland, OH, in 1966-67 and at Tilton School, Tilton, NH, in 1968-69. The educational philosophy guiding these programs was a practical, hands-on problem-solving approach calling for both individual and group work in an environment that encouraged experimentation and discovery rather than lecture and delivery of answers by a conventional teacher or workshop leader. While Chadbourne was Headmaster of Tilton School and running the Tilton water quality workshops, School Librarian, Winifred Talbot, discovered an article on learning theory in 1969 that exactly matched the teaching methodology used in the University and Tilton School models. Upon returning to Cleveland, Ohio, and founding the Institute, Chadbourne adopted that written version as the Institute's educational philosophy. It is excerpted from an article by Gerald J. Pine and Peter J. Horne, "For Learning in Adult Education," published October 1969 in the periodical, *Adult Leadership*.

An activity based on these principles and conditions appears in Part VI, "Learning about Learning: An Environmental Approach."

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meaning on the part of the learner. Unless what is being taught has personal meaning for the individual he will shut it out from his field of perception. People forget most of the content "taught" to them and retain only the content which they use in their work or content which is relevant to them personally.

### PRINCIPLE 2

**Learning is the discovery of the personal meaning and relevance of ideas.** People more readily internalize and implement concepts and ideas which are relevant to their needs and problems. Learning is a process which requires the exploration of ideas in relation to self and community so that people can determine what their needs are, what goals they would like to formulate, what issues they would like to discuss, and what content they would like to learn. Within broad programmatic boundaries what is relevant and meaningful is decided by the learner(s), and must be discovered by the learner.

### PRINCIPLE 3

**Learning (behavioral change) is a consequence of experience.** People become responsible when they have really assumed responsibility, they become independent when they have experienced independent behavior, they become able when they have experienced success, they begin to feel important when someone likes them. People do not change their behavior merely because someone tells them to do so or tells them how to change. For effective learning [to take place], giving information is not enough, i.e., people become responsible and independent not from having other people tell them that they should be responsible and independent but from having experienced authentic responsibility and independence.

### PRINCIPLE 4

**Learning is a cooperative and collaborative process.** Cooperation fosters learning -- "Two heads are better than one." People enjoy functioning independently but they also enjoy functioning interdependently. The interactive process appears to "scratch and nick" people's curiosity, potential, and creativity. Cooperative approaches are enabling. Through such approaches people learn to define goals, to plan, to interact and to try group arrangements in problem solving. Paradoxically, as people invest themselves in collaborative group approaches they develop a firmer sense of their own identification.

They begin to realize that they count, that they have something to give and to learn. Problems which are identified and delineated through cooperative interaction appear to challenge and to stretch people to produce creative solutions and to become more creative individuals.

## PRINCIPLE 5

**Learning is an evolutionary process.** Behavioral change requires time and patience. Learning is not a revolutionary process. When quick changes in behavior are demanded we often resort to highly structured procedures through which we attempt to impose learning. Whether such learning is lasting and meaningful to the learner is doubtful. Implicit in all the principles and conditions for learning is an evolutionary model of learning. Learning situations characterized by free and open communication, confrontation, acceptance, respect, the right to make mistakes, self-revelation, cooperation and collaboration, ambiguity, shared evaluation, active and personal involvement, freedom from threat, and trust in the self are evolutionary in nature.

## PRINCIPLE 6

**Learning is sometimes a painful process.** Behavioral change often calls for giving up the old and comfortable ways of believing, thinking, and valuing. It is not easy to discard familiar ways of doing things and incorporate new behavior. It is often "downright" uncomfortable to share one's self openly, to put one's ideas under the microscope of the group, and to genuinely confront other people. If growth is to occur pain is often necessary. However, the pain of breaking away from the old and the comfortable is usually followed by appreciation of and pleasure in the discovery of an evolving idea or changing self.

## PRINCIPLE 7

**One of the richest resources for learning is the learner himself.** In a day and age when so much emphasis is being placed on individual instructional media, books, and speakers as resources for learning, we tend to overlook perhaps the richest resource of all -- the learner himself. Each individual has an accumulation of experiences, ideas, feelings, and attitudes which comprise a rich vein of material for problem-solving and learning. All too often this vein is barely tapped. Situations which enable people to become open to themselves, to draw upon their personal collection of data, and to share their data in cooperative interaction with others maximize learning.

### PRINCIPLE 8

**The process of learning is emotional as well as intellectual.** Learning is affected by the total state of the individual. People are feeling beings as well as thinking beings and when their feelings and thoughts are in harmony learning is maximized. To create the optimal conditions in a group for learning to occur, ***people must come before purpose.*** Regardless of the purpose of a group, it cannot be effectively accomplished when other things get in the way. If the purpose of the group is to design and carry out some task, it will not be optimally achieved if people in the group are fighting and working against each other. If the purpose of the group is to discuss current issues and problems in a given field with reason and honesty, then it will not be achieved if people are afraid to communicate openly. Barriers to communication exist in people, and before we can conduct "official business" we need to work with the people problems that may exist in a group. It might be said that in any group, regardless of the people problems which exist, enough group intellectual capacity remains intact for members of the group to acquire information and skills. However, to maximize the acquisition and internalization of ideas it seems reasonable that the people problems would have to be dealt with first.

### PRINCIPLE 9

**The process of problem solving and learning is highly unique and individual.** Each person has his own unique styles of learning and solving problems. Some personal styles of learning and problem solving are highly effective, other styles are not as effective, and still others may be ineffective. We need to assist people to define and to make explicit to themselves the approaches they ordinarily use so that they can become more effective in problem solving and learning. As people become more aware of how they learn and solve problems and become exposed to alternative models used by other people they can refine and modify their personal styles so that these can be employed more effectively.

## II. CONDITIONS WHICH FACILITATE LEARNING

### CONDITION 1

**Learning is facilitated in an atmosphere which encourages people to be active.** The learning process thrives when there is less teacher (group leader) domination and more talk and more faith that people can find alternatives and solutions satisfying to themselves. Listening to people and allowing them to use the teacher (group leader) and the group as a resource and a sounding board, facilitates the active exploration of ideas and possible solutions to problems. People are not passive and reactive receptacles into which we can pour the "right" values, the "right" answers, and the "right" ways of thinking. People are active and creative beings who need the opportunity to determine goals, issues to be discussed, and the means of evaluating themselves. They learn when they feel they are a part of what is going on -- when they are personally involved. Learning is not poured into people, learning emerges from people.

## CONDITION 2

**Learning is facilitated in an atmosphere which promotes and facilitates the individual's discovery of the personal meaning of ideas.** This means that the teacher (group leader) rather than directing or manipulating people helps them to discover the personal meaning of ideas and events for them. He creates a situation in which people are freely able to express their needs rather than having their needs dictated to them. Learning becomes an activity in which the needs of the individual and the group are considered in deciding what issues will be explored and what the subject matter will be.

No matter how permissive or unstructured a learning activity may be, there exist implicit goals in the activity itself -- a group leader (teacher) is never goalless. Learning occurs when the goals of the leader accommodate, facilitate, and encourage the individual's discovery of personal goals and personal meaning in events. The art of helping people to change their behavior requires the development of goals which provide sufficient elbow room for people to explore and internalize behavior satisfying and growth-producing to themselves.

## CONDITION 3

**Learning is facilitated in an atmosphere which emphasizes the uniquely personal and subjective nature of learning.** In such a situation, each individual has the feeling that *his* ideas, *his* feelings, *his* perspectives have value and significance. People need to develop an awareness that all that is to be learned is not outside or external to themselves. They develop such an awareness when they feel their own contributions and their value as people are genuinely appreciated.

## CONDITION 4

**Learning is facilitated in an atmosphere in which difference is good and desirable.** Situations which emphasize the "one right answer," the "magical solution," or the "one good way" to act or think or to behave both narrow and limit exploration and inhibit discovery. If people are to look at themselves, at others, and at ideas openly and reasonably, then they must have the opportunity to express their opinions no matter how different they may be. This calls for an atmosphere in which different ideas can be *accepted* (but not necessarily agreed with). Differences in ideas must be accepted if differences in people are to be, too.

## CONDITION 5

**Learning is facilitated in an atmosphere which constantly recognizes people's right to make mistakes.** Where mistakes are not permitted, then the freedom and the willingness of people to make choices are severely limited. Growth and change are facilitated when error is accepted as a natural part of the learning process. The learning process requires the challenge of new and different experiences, the trying of the unknown, and therefore necessarily must involve the making of mistakes. In order for people to learn, they need the opportunity to explore new situations and ideas without being penalized or punished for mistakes which are integral to the activity of learning. The teacher (group leader) who feels and acts on the need to be always right creates a limiting and threatening condition to learning.

## CONDITION 6

**Learning is facilitated in an atmosphere which tolerates ambiguity.** In a rigid and defensive atmosphere people feel they cannot take the time to look at many solutions, they feel highly uncomfortable without answers, and they feel there is more concern for "right" answers rather than good answers. The open and fearless exploration of solutions calls for time to explore many alternatives and time to proceed without feeling and pressures for immediate and forthcoming answers.

## CONDITION 7

**Learning is facilitated in an atmosphere in which evaluation is a cooperative process with emphasis on self-evaluation.** If learning is a personal process, then people need the opportunity to formulate the criteria to measure their progress. Criteria established by the teacher (group leader) are mostly artificial and irrelevant to persons in a group. Usually behavioral change and growth are measured by the degree to which people can regurgitate what others have tried to spoonfeed them. It is obvious that anyone can play the game of "giving the teacher what he wants." A more viable and meaningful evaluation occurs when people are free to examine themselves and the roles they play with other people. Self evaluation and peer evaluation enable people to really judge how much they have learned and grown, e.g., through audio and/or video tape recordings of their behavior people can see themselves in the process of learning. Such recordings provide tangible and concrete evidence of progress and provide a rich source of material to the group for learning. New insights evolve as people see themselves as they really are. For learning to occur the individual in the group needs to see himself accurately and realistically. This can be best accomplished through self and group evaluation.

## CONDITION 8

**Learning is facilitated in an atmosphere which encourages openness of self rather than concealment of self.** Problem solving and learning require that personal feelings, attitudes, ideas, questions, and concerns be openly brought to light and examined. To the degree that an idea, a thought, a feeling, or an attitude related to the topic at hand is held back and not openly expressed -- to that degree are the processes of learning and discovery inhibited. People need to feel that they can try something, fail if necessary without being humiliated, embarrassed, or diminished as persons. Openness of self occurs in an atmosphere free from psychological threat. People can invest themselves fully and openly in the collaborative and interactive process of learning when they know that no matter what they say or express, it will not result in psychological punishment or penalties.

## CONDITION 9

**Learning is facilitated in an atmosphere in which people are encouraged to trust in themselves as well as external sources.** They become less dependent upon authority when they can open up the self and when they feel that they have something to bring to the learning situation rather than the feeling that all learning means the acquisition of facts and knowledge form some external agent for use sometime in the future. People learn when they begin to see *themselves* as the wellsprings of ideas and alternatives to problems. Learning is facilitated when people begin to draw ideas from themselves and others rather than relying on the teacher (group leader).

## CONDITION 10

**Learning is facilitated in an atmosphere in which people feel they are respected.** In a group in which high value is placed upon the individuality of the members and upon the relationships that exist within the group, people learn that someone cares for them. A genuine expression of care *on the part of the teacher (leader)* and a warm emotional climate generate an atmosphere of safety in which people can explore ideas and genuinely encounter other people without any threat. Confrontations and differences of opinion become constructive forces in a group in which people experience that they are respected as persons. A safe atmosphere need not exclude personal confrontations which often are effective catalysts for learning.

## CONDITION 11

**Learning is facilitated in an atmosphere in which people feel they are accepted.** People are free to change when they feel that change isn't being imposed upon them. It's paradoxical, but the more we try to change people the more resistant they become to change. A person must *be* before he can *become*. Accepting a person means that we allow him to hold his values and to be himself. When a man does not have to defend himself or his values, then he is free to take a look at himself and to change. An insistence on change contains an implicit note of rejection. In effect, we say to people, "I can't accept you as you are; you must change." People need to feel they have an option -- to change or not to change. They develop this feeling when they experience that they are accepted for who they are. When people or their values are attacked, it is natural that they will defend themselves. People who are busy defending themselves are not free to learn.

## CONDITION 12

**Learning is facilitated in an atmosphere which permits confrontation.** With free and open communication, with a non-threatening psychological climate, the unique self of each person is expressed. It is inevitable that in such a situation persons will confront persons, ideas will challenge ideas. Confrontations facilitate learning. They provide opportunities for people to have their ideas and themselves viewed and tested from the framework of other people or the group. No man learns in isolation from other people. His behavior changes and his ideas are refined and modified on the basis of the feedback he gets from other people. Confrontation is a proving ground which enables ideas to be synthesized, new ideas to emerge, and people to change.

# WHY REDUCE, REUSE, AND RECYCLE?

## A. Because of the Federal Government's " Agenda for Action"

In 1988, the U.S. EPA prepared "An Agenda for Action" that commits the federal government to a new leadership role in solid waste management. The report included promoting national source reduction and recycling, including a 25% source reduction /recycling goal to be reached by January 1992, and the Agenda established the hierarchy of waste managemnt planning options of reuse, waste reduction, recycling, resource recovery, incineration, and lastly, landfilling.

Thus, counties, cities, businesses, schools, and individuals all have to start reducing their waste by changing purchasing policies and by recycling as much as possible. Schools are particularly important in this process because of their dual role as both waste generators and centers of education for students and their families.

## B. Because the Planet's Resources Are Limited.

Humans cannot continue a one-way trail of materials in which products are used and then thrown away; many of our resources are being depleted rapidly. In the **natural** cycles which materials (such as water) go through there is infinite reuse and recycling. This is what humans must start doing with **all** materials, from pop cans to industrial waste. Consumers must make choices about whether or not a product should be purchased, based on the amount and type of resources from which it is composed and whether or not they can be reused or recycled. Once purchased, every material must be used to its fullest extent.

## C. To Reduce Waste Disposal Costs and Bring in Revenue from Materials Formerly Thrown Away.

Less volume in the waste stream means lower disposal costs. In addition, materials such as high-grade paper, aluminum, and other recyclables are worth money. As a result, schools can save or make money on materials they once paid to throw away.

## D. To Help Strengthen Urban Economies and Create Jobs.

City planners see recycling as a new industry which, with its inexpensive source of feedstock, can help rejuvenate faltering urban economies and provide jobs. Many Asian paper mills, for example, run entirely on recycled feedstock, much of which is imported

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from the USA. If the USA keeps these materials and uses them for its own manufacturing plants, our country will be more competitive globally. By recycling as much as possible, schools help to further US economic goals.

### E. To Help Students Learn by Tying Classroom Concepts about Waste to the Realities of Waste in Homes and School Buildings.

Some concepts that students learn in the classroom seem irrelevant because students have no real-world application of the concepts. When students are learning about recycling and other issues concerning resources, they can actually practice what they learn at school and at home by doing waste stream audits and participating in reduction and recycling programs. Studies have shown that hands-on activities are highly successful in helping students to learn concepts and to understand their usefulness in everyday life.

# THE WASTE HIERARCHY - BACKGROUND ON EPA GUIDELINES

In 1989, faced with national shortages in landfill space and problems with toxic materials leaching from landfills into groundwater supplies, the US EPA prepared a report entitled *The Solid Waste Dilemma: An Agenda For Action*. This document set a national goal of 25% recycling of all waste in the United States by 1992.

The *Agenda for Action* also set in place a new hierarchy for the management of solid waste, as part of an integrated system. In order of preference, the hierarchy is this: **reduce, reuse, recycle, incinerate, landfill**. The aim is to reduce the amount of waste sent to landfills from the current 73% and increase the amount of waste recycled and incinerated from the current 13% and 14%, respectively.

Each element of the hierarchy is important in an integrated waste management system, but this manual focuses on only two of them, **reduction** and **recycling**. Recycling is the easiest element for schools to manage the waste they now generate, and to save money and earn revenue from materials recycled.

However, it is even more important over the long term to **reduce** waste generated in the first place by purchasing materials with less packaging, not buying unnecessary items, and **reusing** materials as many times as possible. Reducing waste is something that everyone can do -- children and adults, in institutions and homes, at large and small companies. It is a part of the hierarchy often neglected because we are so concerned about disposing of the waste that we do generate. But, the emphasis in schools should be on reduction and reuse as much as possible. Students will learn that money and time are saved by not generating the waste in the first place. Recycling then assumes a less important role.

**Incineration** is also part of the hierarchy. This process reduces the **volume** of waste. Energy generation can also be a useful by-product of incineration. However, there are many economic and environmental concerns about incineration, including the expense of building and maintaining facilities, the tendency towards inefficiency, the toxic air pollution and ash created, and the overall wisdom of burning finite resources for a one-time burst of energy instead of finding ways to reuse the materials.

**Landfilling**, once the primary method for waste disposal, is now seen as the last resort. But there will probably always be a need for landfills to house those materials which cannot be reduced, reused, recycled, or incinerated, (e.g., incinerator ash). New technologies make landfills safer and less likely to leach toxics into the environment. It is now common to capture the methane gas produced by landfills and use it as fuel.

# PART I

## EVERYTHING ENDS UP SOMEWHERE

- *The Problem of Solid Waste*
- *Alternatives to Incineration and Landfilling*
- *Developing a School Reduction, Reuse, and Recycling Program*

# PART I

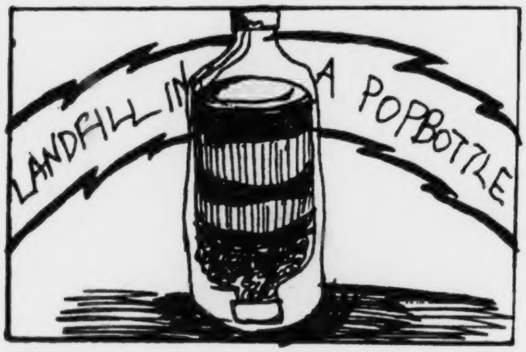
## EVERYTHING ENDS UP SOMEWHERE

- *The Problem of Solid Waste*

# LANDFILL IN A POP BOTTLE

**Subjects:** Science, biology, chemistry, environmental science, health

**Format:** Individual student, team, or entire class; one period preparation and one period follow-up to report findings



**OBJECTIVE:** To demonstrate the function served by the modern sanitary landfill and to assess its merit as a waste management method.

**METHOD:** Students construct model landfills to compare different containment techniques and to examine how they function over time.

**BACKGROUND:** Up until the late 1960s, few regulations governed the operation of open dumps in the United States. Today, citizens are paying the price. For example, at the present time, there are an estimated 168 old landfills throughout the state of Ohio that require immediate clean-up. Ohio EPA estimates that remediation measures in the state will cost at least $2.6 billion. Nationwide, the number of sites requiring clean-up has outstripped the available funding.

The primary cause for concern is the threat that landfills pose to local groundwater supplies. Every time it rains, water percolates through the volumes of garbage. In the process, this water leaches heavy metals and other hazardous materials from such common discards as automotive batteries, paints, and cleaners. The resulting liquid, or "leachate," eventually collects at the base of a landfill, often in considerable quantities. Fresh Kills, the primary repository for the waste produced in New York City, generates an estimated 2,000,000 gallons of leachate per day. According to one source, this brew can be up to 200 times as toxic as raw sewage. If it leaks from the landfill and reaches the water table, it can seriously contaminate groundwater. With over half of all Americans dependent on groundwater for their drinking water needs, contaminated groundwater constitutes a significant problem.

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In response to growing discoveries about landfill leachates, government officials are increasing measures to safeguard the public health. States are passing legislation that has greatly restricted the practice of open dumping. Existing facilities are now subject to inspection and permitting by local health departments. In addition, new facilities have to incorporate special design features. Termed **sanitary landfills**, these new solid waste dumps must include a synthetic membrane to contain the site. In addition, landfill operators must install a leachate collection system to remove the toxic liquid that gathers at the base of the landfill and conduct methane monitoring to ensure that gases given off by the decaying garbage do not become a health risk (see Diagram A at the end of the activity). Once landfill sites have reached capacity, they must be capped and monitored for a thirty-year period. In the past, such sites were often simply landscaped and used for parks and housing developments. However, problems resulted from the build-up of explosive methane gas (due to bacteria slowly digesting the garbage) and the settling of buried trash. As a result, this practice is now being discouraged.

Despite the added design features, the U. S. EPA estimates that all landfills will leak at some point in their lifetime. In addition, landfilling is inherently wasteful. Instead of being treated as a raw material and used to make new products, landfilled materials are sent to their final resting place, lost to us forever.

## MATERIALS:

- 4 rinsed 2-liter pop bottles and caps
- 1/2 -gallon bucket of gravel
- 1-gallon bucket of regular soil (do not use potting soil)
- 3-inch swatch of cheesecloth or nylon stocking
- 1 plastic food bag
- Scissors, tape, 2 rubberbands, utility knife
- Assorted pieces of garbage (apple cores, banana peels, bread, leaves, aluminum foil, bottle caps, rubberbands, paper clips, pennies, cloth, newspaper, copy paper, plastic scraps)

**PROCEDURE:** Cut two 2-liter bottles in half: for safety, make an incision with the utility knife and then let the students cut around the bottles with scissors (see

Diagram B at the end of the activity); if any of the edges are jagged, trim them with scissors; these halves will serve as the base and cap of your two model landfills; remove the base cup from each of the two remaining bottles; then cut the bottoms off half an inch below the point where the bottles begin to taper down; cover the top and neck of one with cheesecloth or nylon stocking and secure it with a rubberband; cover the top and neck of the other with the plastic food bag and secure it in a similar fashion; each of these two bottles will form the body of your model landfills.

Now turn the first bottle (with the cheesecloth) upside down and insert it in the bottom half of one of the original bottles; repeat this step on the second bottle (with the plastic food bag), placing it neck-down in the bottom half of the other bottle.

Fill each model with a 2-inch layer of gravel followed by a 1-inch layer of soil; then sandwich two 2-inch layers of assorted garbage around a 1/2-inch layer of soil; top the second layer of garbage with a 1 1/2-inch layer of soil (see Diagram C at the end of the activity). Now that the body of each landfill has been prepared, gradually pour two cups of water on top to simulate rainfall; cap each landfill with the top half of the original bottles. You have constructed two landfills, one that leaks and one that is sealed. When storing model landfills, keep them in a dark room or at least away from direct sunlight to simulate landfill conditions.

Ask students to examine what happens to each of the landfills over a period of several weeks. At the beginning of each week, ask them to record their observations. In each case, encourage them to check for the presence of leachate in the base of each landfill. In addition, ask them to record from week to week any changes in the various items of garbage in the landfill. (If you wish to include "leachate" testing -- see Section C under "Variations," below -- after the students record their observations, ask them to remove the leachate from the base of the landfill. Then, ask them to pour one cup of water on top of the landfill and replace the cover. Leachate can be tested from time to time and compared for pH, color, odor, etc.)

**DISCUSSION/QUESTIONS:** At the end of the activity, ask the students to report their findings. Compare what happened in the two types of landfills.

A. Which items, if any, decomposed? Why?

B. How much leachate did each landfill generate? Where did it end up?

C. What are the implications of your leaking landfill?

D. How does a leaking landfill present a problem for the surrounding community?

E. How can you counteract leakage? (Note that in minimizing leakage through added design features, the cost of landfilling goes up.)

F. List alternatives to landfilling garbage.

G. What are the pros and cons of landfilling versus the pros and cons of incinerating, recycling, etc.?

H. What items in the landfills (including the containers themselves) should be reused, recycled, or disposed of after the activity? (If they are unsure, assign students to learn the County's or their individual municipality's policies for each item. For example, most communities recycle the two-liter PETE [polyethylene terephthalate]; organic wastes such as banana peels, leaves, etc. should be mulched; pennies should be reused; newspaper can be mulched; plastic scrap, identifiable by type -- especially Numbers 1 and 2, PETE and HDPE [high density polyethylene, as found in milk jugs], may be recycled; aluminum foil can be recycled; cloth, if cotton, silk, wool, or other all natural fiber, can be mulched.)

## VARIATIONS:

A. Teachers may want to add a mini compost container to the experiment to demonstrate what happens to trash when it is exposed to air and water. In order to do this, refer to the activity entitled "Striking It Rich with Classroom Composting." At the end of four weeks, ask the students to compare what happened in the model landfills with what happened in the mini compost heap.

B. To add fun and competition, have each student name his or her landfill and then have the class vote on the most creative name.

C. Students can actually test the leachate that forms at the bottom of the leaky landfill. In order to do this, ask them to remove the leachate that has collected in the base cup at the end of each week. Then have them run a battery of tests on the liquid.

Test for the following properties:

- Acidity (using litmus paper)
- Suspended solids (drain it through a coffee filter)
- Dissolved solids (boil off the liquid and examine and weigh the residue)

In addition, the leachate can be tested biologically by planting test plots of seeds and watering them with the leachate (additional seeds watered with distilled water can serve as a control). Compare the number of seeds that germinate. Graph your results for the chemical, physical, and biological tests.

## FURTHER STUDY:

A. Ask students to make a map of current and former landfills in the community. Ask if they can think of reasons why landfills might be placed in certain areas (i.e., areas of low population, economically depressed areas, etc.) and what their impact might be on the surrounding community.

B. Assign students to search local media archives for stories about problems with those landfills in the local community. Ask them to note the types of remediation used and the extent to which such measures were successful in alleviating the expressed problems.

## SOURCES:

Bottle Biology Resources Network. "Compost Column." Madison: University of Wisconsin, March 1990.

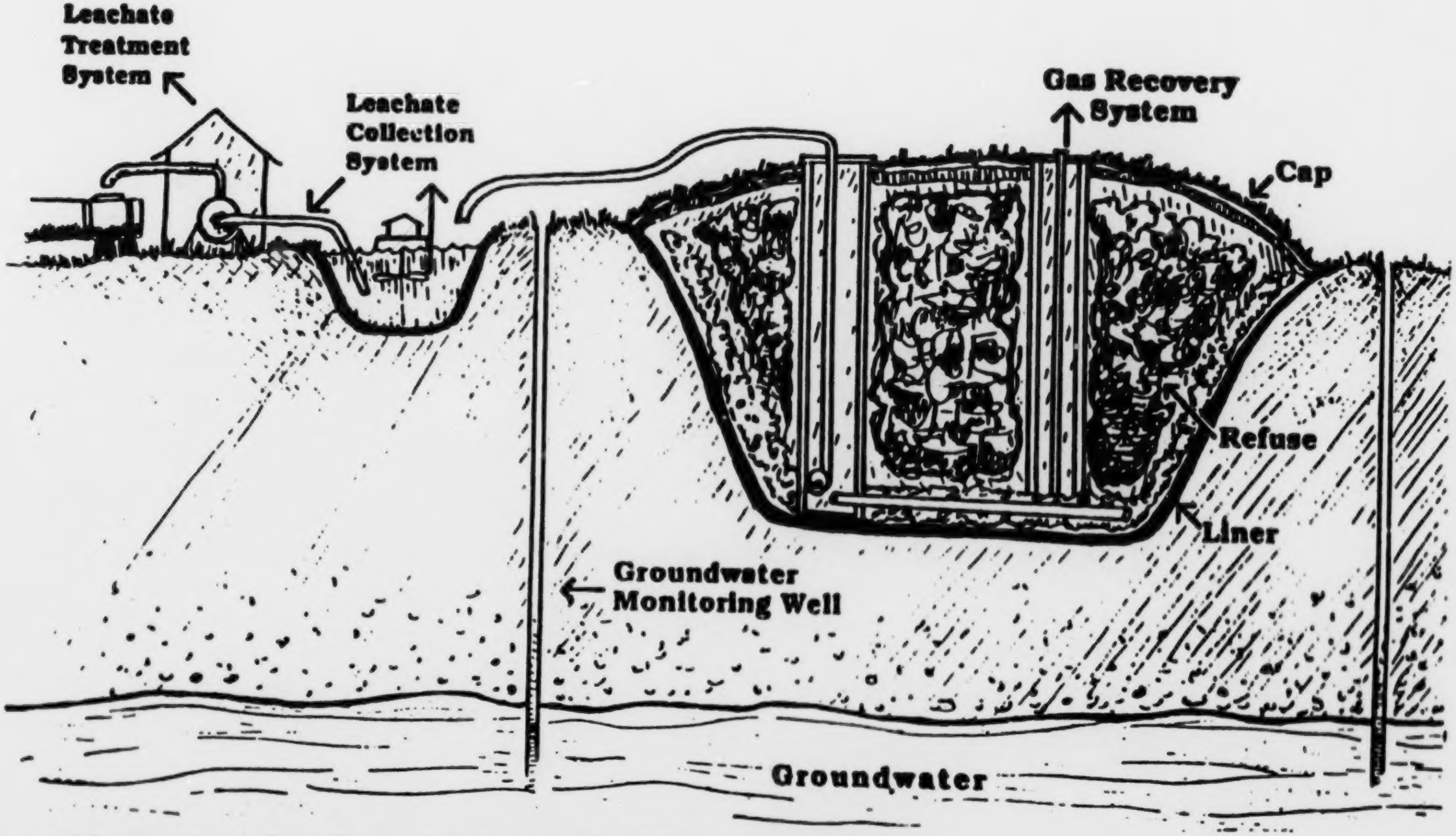
Jones, Linda Cronin. *4Rs Project: A Solid Waste Management Curriculum for Florida Schools, Ninth through Twelfth Grade.* Tallahassee: Florida Department of Education, 1990.

## ACKNOWLEDGEMENTS:

Our thanks to Ben Hitchings for writing this activity, based on the concepts presented in the Florida and Wisconsin works cited above.

# DIAGRAM A

## A MODERN LANDFILL



Leachate Treatment System
Leachate Collection System
Gas Recovery System
Cap
Refuse
Liner
Groundwater Monitoring Well
Groundwater

Graphic reprod [illegible] vith the permission of the Florida Department of Education from its *4 Rs Proj* [illegible] *Solid Waste Management Curriculum for Florida Schools.*

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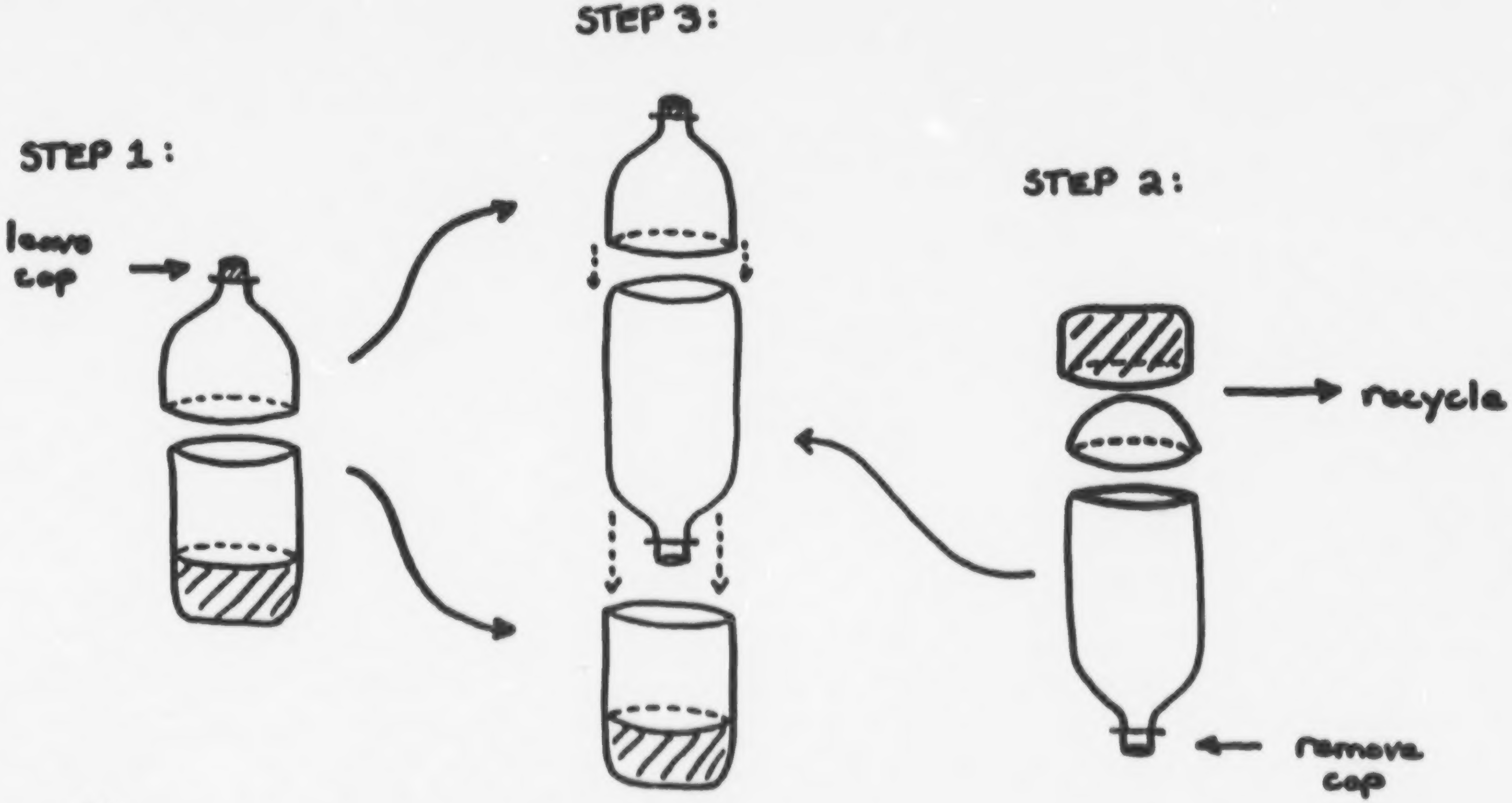
# DIAGRAM B

## Landfill Construction

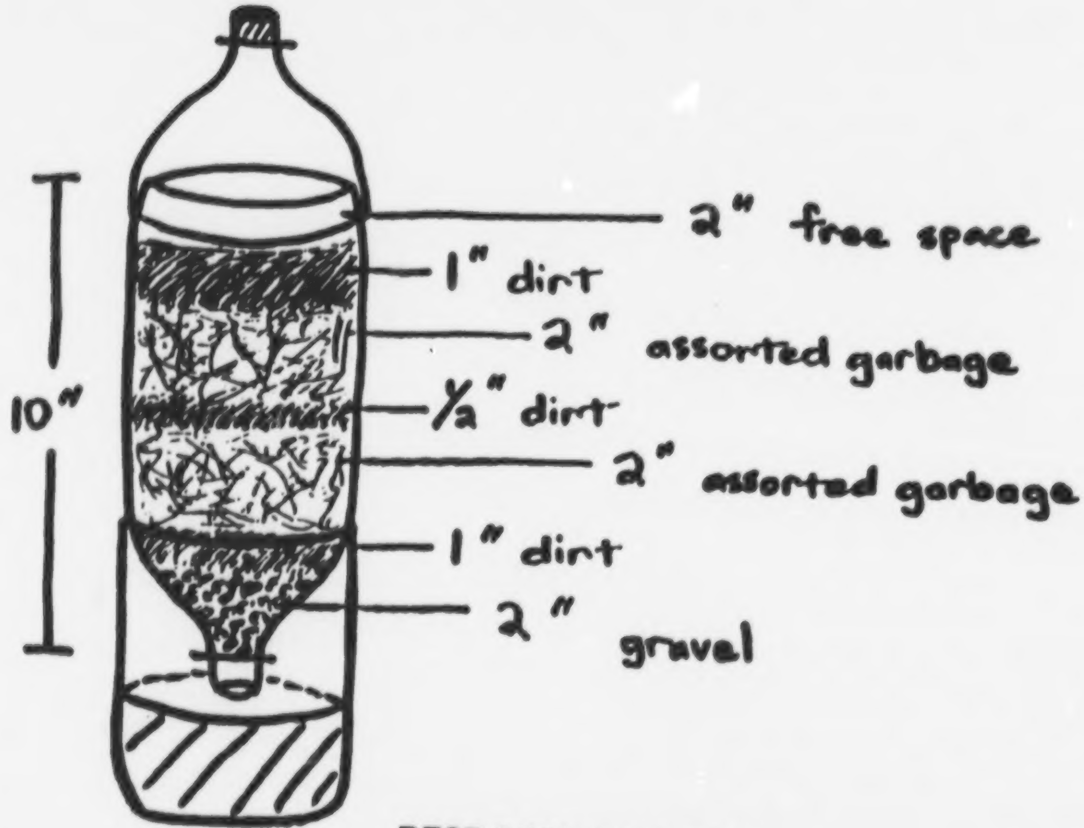

STEP 3:
STEP 1:
leave cap
STEP 2:
recycle
remove cap

41

42

## DIAGRAM C

## Layers in the Landfill


10"
2" free space
1" dirt
2" assorted garbage
½" dirt
2" assorted garbage
1" dirt
2" gravel

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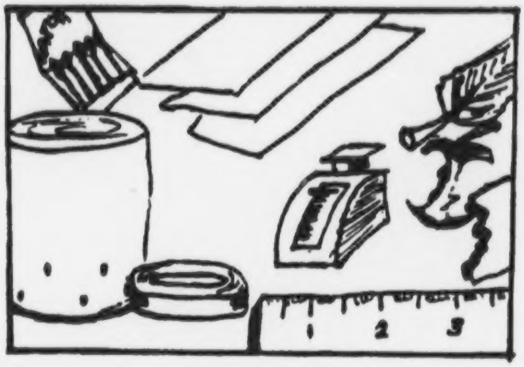
# TO BURN OR NOT TO BURN

**Subjects:** Government, science, physical science, environmental science, geography, chemistry, physics, health, economics, speech, language arts

**Format:** Individual student investigation, team project, or full class activity & discussion; 2 class periods; expandable with add-on studies



**OBJECTIVE:** Students will (1) identify and describe two types of waste-to-energy (energy recovery) systems; (2) conduct an experiment using a model incinerator to help them characterize the process and the outcomes from burning materials; (3) calculate the effects of incineration on the volume and mass of materials burned; (4) present their findings in both oral and written forms, arguing for and against this waste treatment option.

**METHOD:** Students will incinerate material in a model (tin can) incinerator, document their findings, and then report orally and in writing their cases for and against this waste treatment option. **WARNING: No plastics should be burned for this activity.** (See warnings about burning plastics in activity titled "Plastic Polymers.") A teacher should supervise closely the actual burning of material during this activity; in addition, the burning should be done outdoors or in a well-ventilated laboratory. (The teacher can also do the incineration of materials beforehand, bringing in the resulting ash from burning raw materials, along with an identical batch of the raw materials that generated the ash.)

**BACKGROUND:** Until recently, most communities disposed of their solid waste in open dumps or by burning it in incinerators. Today, both options are criticized as poor waste management choices: the open dumps because of their threat to groundwater supplies, their attraction of vermin and other harmful organisms, and their potential for fires and other threats to people living near them; the conventional incinerators because of the air pollution they cause from ash and toxic gases. Because

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of these environmental concerns, open dumps have been replaced by sanitary landfills which must be built and managed to EPA specifications, while conventional incinerators have been replaced by modern waste-to-energy facilities with numerous environmental controls for managing the volume and toxicity of emissions. Burning and landfilling -- are the least desirable alternatives under the federal government's waste hierarchy (which is reduce, reuse, recycle, incinerate and, lastly, landfill). For this reason, many communities find themselves in a quandary over how best to serve their citizens' needs.

Waste to energy plants, also called resource recovery facilities, are expensive methods for disposing of large amounts of solid waste. Two types of waste-to-energy facilities are "mass burn" facilities and "refuse-derived fuel" (RDF) facilities. Mass burn facilities burn solid waste as it is delivered to them, without any separation of recyclables either before or after incineration. (Ideally, recyclables would be separated from the waste material before it is delivered to the facility.) Refuse-derived fuel facilities remove recyclables from the waste material before burning. Both kinds of facilities shred or process waste and burn it at high temperatures, up to 2500°F to produce energy in the form of steam heat or electricity. RDF plants produce fuel pellets which can then be burned, although the plant itself may not burn them as fuel but may sell them to others.

Over 100 waste-to-energy plants operate in the U. S., and nearly 100 more are in the advanced planning stage or under construction. Nationally, these plants burn about 14% of the country's solid waste.

The benefits of waste-to-energy incineration are:

- Lessening the need for new landfills and extending the life of existing ones. (These facilities can reduce the volume of solid waste by as much as 90%.)
- Conserving recyclable resources, such as metals, paper, plastic, and glass.
- Generating revenues for the communities from "tipping fees" (charges levied against those dumping their wastes at the facility) and from the sale of the steam heat or electricity generated. (These revenues can also partially offset the costs of building, operating, and maintaining the facility.)

The disadvantages of waste-to-energy incineration are:

- Some 10% or more of the solid waste burned in such facilities remains as residual ash. It contains heavy metals and other toxic materials, and must be disposed of in landfills. Even in fully lined landfills, this ash poses a threat to groundwater supplies.

- During the combustion process, large amounts of carbon dioxide ($CO_2$) and small amounts of dioxin (a proven carcinogen, or cancer-causing chemical) are emitted to the air.

- Waste-to-energy facilities are expensive to build (e.g., $100 million per 1,000 tons of capacity).

- Some resource analysts argue that the high, steady volume of waste required by these facilities **discourages** communities from reducing, reusing, or recycling materials. Once such a facility is built, the city is often obligated to supply it with waste . If the facility is designed to process 100 tons per day, the city may be legally obligated to supply it with that much waste, even if it has to **import** waste from other communities.

In the general case, waste-to-energy facilities should be considered for (1) areas where an aggressive reduce/reuse/recycle program already exists, (2) extremely high volumes of solid waste, and (3) locations with little landfill space available. However, since landfills are filling so rapidly and regulations governing the permits for new ones are so stringent, this last point will be true for a great many communities. Then the question becomes one of balancing resource use with the community's needs and best interests.

## MATERIALS:

- "Waste-to-Energy Facility" transparency

- "To Burn or Not to Burn" student worksheets -- 1 per student or team of students

- Balances or scales for weighing the waste prior to incineration and for weighing the ash afterward

- For each student or team of students a 3 lb. coffee can or an empty 1- gallon paint can -- both should have several vent holes punched in the sides one inch from the bottom of the can

- A heavy-duty metal screen to top the can

- Five 4" to 6" pieces of cardboard

- Masking tape

- Paper and food waste to fill a 4"x4"x4" to 6"x6"x6" box (e.g., egg shells, notebook paper, orange rinds, napkins, bread scraps; these ingredients may be varied to allow students to compare the relative masses, volumes, and residues for various wastes.)

- Ruler

- Matches

# PROCEDURE:

A. Define the terms "incineration" and "waste-to-energy"; briefly describe the two types of waste-to-energy facilities (mass burn and RDF).

B. Project the "Waste-to-Energy Facility" transparency and review the basic steps of the facility's operation.

C. Give students instruction on how to proceed as either individual experimenters or as team members. Distribute materials to them. Review, if necessary, the mathematical formulas for calculating mass, volume, and averages. Review carefully the safety precautions needed for conducting this experiment.

D. Pass out the "To Burn or Not to Burn" worksheet and instruct the students to complete the following experiment:

   1. Tape 5 cardboard pieces together to form a box with 4 sides and a bottom.

   2. Use a balance or scale to determine the mass of the empty box.

   3. Fill the box completely with paper and food waste; reweigh the box once filled to determine the mass of the waste (weight of box filled minus weight of empty box).

   4. Calculate the volume of the solid waste in the box (length x width x height of the box equals the number of cubic inches).

   5. Pour the waste from the box into a vented can and cover the can opening with the screen.

6. In a well ventilated area, light the waste with a match and allow it to burn completely.

7. Record visual and olfactory observations during the incineration process.

8. Once burning is complete and the ashes have cooled, pour the ashes and any unburned waste back into the cardboard box.

9. Weigh the box to determine the weight of the ash and unburned material (weight of box, ashes and unburned material minus the weight of the empty box).

10. Spread out the residual ashes and waste in the box on a table top and, using a ruler, determine the volume of the residue (i.e., arrange in as uniform a pile as possible, and take length, width, and depth measurements and then calculate the volume. To determine the difference in volume between the initial waste and the residue waste, subtract the residue volume from the initial waste volume.)

E. After the incineration has been completed and records made, discuss the following with the students:

1. How do their visual and olfactory records compare?

2. On a chalkboard or overhead, record each group's calculations of the percent reduction in the mass and volume of solid waste incinerated. Ask students to determine a class average of the percent reduction in mass and volume for solid waste incinerated.

F. Ask students to identify the potential benefits and problems of this waste management choice.

## DISCUSSION/QUESTIONS:

Discuss the following:

A. Should such facilities be privately owned or government owned? Present arguments for both sides.

B. How would they address this scenario? Community X installed a community owned mass burn facility 5 years ago. It has been handling all their solid waste needs, with only ash being landfilled. They have a projected 20 years of landfill space left at their current rate of use. A citizen action group has sponsored and passed an aggressive reduce/reuse/recycle program for the community. Once implemented, it will reduce the solid waste volume to the mass burn facility by 60% within two years. Such a reduction will destroy the facility's financing plan, i.e., the sale of steam heat to pay for the building, operation, and maintenance of the facility. Dividing the students into problem-solving groups, ask each group to present solutions to the dilemma.

C. How can the health effects on a community from a waste-to-energy facility be accurately determined? What data would be needed?

D. How can a community learn precisely what air emissions are coming from the stacks?

# FURTHER STUDY:

A. Assign students to learn the following facts about their community:

1. What is its policy on residential outdoor burning? What is the basis for that policy?

2. What is the history, if any, of waste-to-energy facilities being proposed for or near the community? What were the issues? Outcomes? Ask students to report on their findings.

3. Have any communities come up with ways to have **both** an aggressive reduce/reuse/recycle program and mass-burn or RDF facilities? If so, how have the resource allocation conflicts been resolved?

4. Assign student teams to debate the pros and cons of such facilities; the affirmative and negative teams switch assignments so that students are required to argue the opposing view. (This can be an in-class presentation, a team-teaching assignment, an after-school speech/debate activity, etc.) Ask students to describe their feelings about arguing for both sides of the issue.

5. What are the government regulations on such facilities? Local, state, federal? Ask students to report their findings.

6. Because leachate from landfills can be highly toxic, ask students to research what methods are used to monitor and test existing landfills for leachate.

What can be done about leaking landfills? (See activity titled "Landfill in a Pop Bottle" for further information on leaking landfills.)

B. Conduct further experiments on other flammable materials, such as food and paper waste. Have students compare these results with earlier mass and volume data.

C. Ask students to prepare position papers on the following topics that relate directly to incineration of solid waste. This assignment could also be a judged competition, with fellow students, a community official, or panel of experts awarding a prize to the best argued case:

1. All waste is a resource; therefore, the burning of any waste is the burning of a resource that is lost forever. By the same token, the landfilling of resources also loses them forever because it would be far too costly and dangerous to "mine" existing landfills for the varieties of reusable and recyclable materials they contain. It is irresponsible to destroy or bury resources that belong to future generations. Products that cannot be reused or recycled should be phased out of production or taxed so highly that consumers will not buy them.

2. Technology and basic science have always managed to save mankind from mistakes of the past (e.g., antibiotics to control much of the world's diseases that are spread by unsafe health practices; solar-powered agricultural devices for third-world country farmers unable to afford conventional fossil-fuel powered equipment). It is then reasonable to assume that it will do so in the future. Therefore, to meet the demand for energy that is convenient and cheap, we should rely on waste-to-energy technology. It is likely that safe nuclear energy, affordable solar energy, and the mining of ocean minerals and the mineral resources of other planets will allow us to provide ourselves with the raw materials we need.

D. Another activity, "Acid Rain," in Part III also treats the subject of air emissions. Assign it as an individual investigation or group activity.

## ACKNOWLEDGEMENTS:

Our thanks to the Florida Department of Education for its permission to use and adapt this activity from the activity, "Solid Waste: A Burning Issue," in its *4 Rs Project*.

## Waste-to-Energy Facility

**In most waste-to-energy facilities, the procedure is similar to the following:**

**1. Trucks loaded with solid waste enter a tipping area and unload the trash directly into a large bin.**

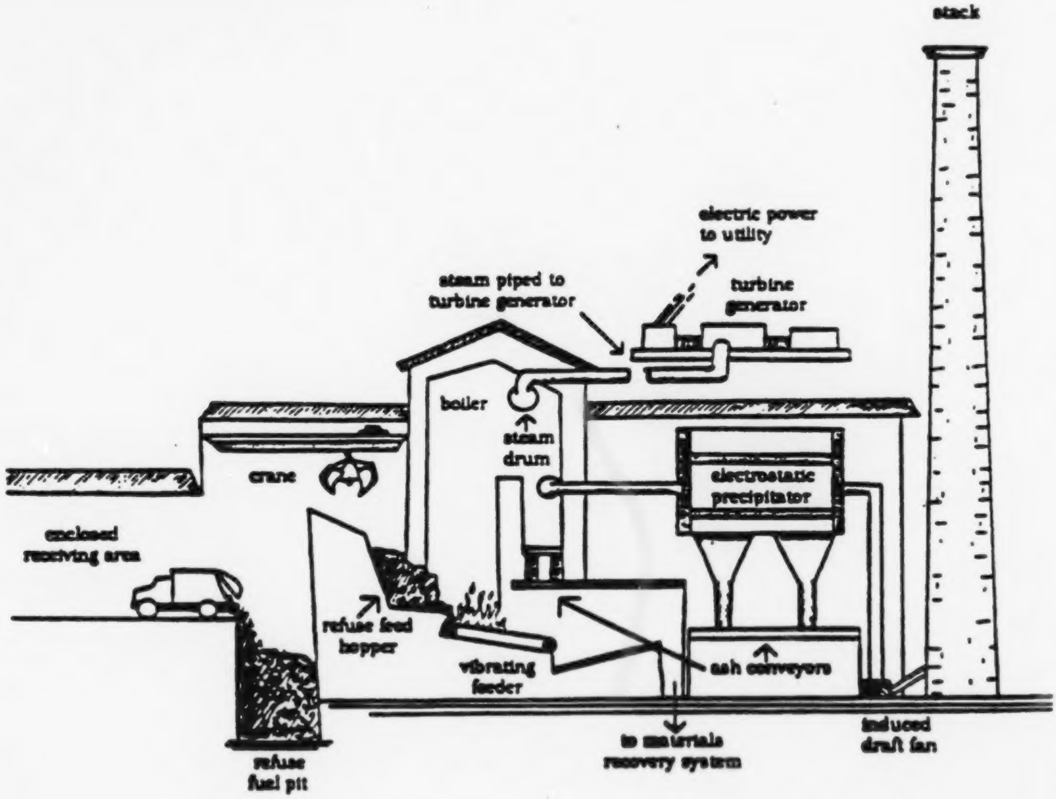
**2. A crane then lifts the waste into a compartment where it is burned.**

**3. A boiler recovers the heat generated from the combustion of the waste.**

**4. Steam produced by the boiler is used for electric power generation.**

**5. The gases produced during the burning process are cleaned and discharged through the emission control system into the atmosphere.**

**6. The remaining ash is removed from the combustion chamber and is disposed of in a secure landfill.**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steam drum
crane
electrostatic precipitator
enclosed receiving area
refuse feed hopper
vibrating feeder
ash conveyors
refuse fuel pit
to materials recovery system
induced draft fan

**Diagram of a mass burn incinerator, one type of waste-to-energy facility. Other types exist, such as refuse-derived fuel facilities.**

**Figure is from the Florida Department of Education's "Solid Waste: A Burning Issue" activity in its *4 Rs Project*.**

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# TO BURN OR NOT TO BURN

**1. Compute the following before incinerating:**

a. Mass of the empty cardboard box: ______

b. Mass of the cardboard box when filled with solid waste: ______

c. Mass of the solid waste (Item b minus Item a): ______

d. Volume of the solid waste (length x width x height): ______

**2. During incineration:**

a. What did you visually observe during incineration about the solid waste and its emissions? ____________________________________________
____________________________________________
____________________________________________

b. What were the odors like, if any were present, during incineration? ______________
____________________________________________
____________________________________________

**3. After incineration:**

a. What was the mass of the residual ash and unburned waste? (Weigh the ash and unburned waste in the box.) ______

b. What was the volume of the residual ash and unburned waste? (Measure the length, width, and depth of the ash and unburned material with a ruler; calculate the volume.) ______

**4. Summary of Effects of Incineration:**

a. Change in mass of solid waste (Item 1-c minus 3-a) ______

b. Change in volume of solid waste (Item 1-d minus 3-b) ______

c. Percent reduction in mass of solid waste from incineration: (Divide the change in mass, 4-a, by the mass before incineration, 1-c, and multiply by 100.) ______

d. Percent reduction in volume of solid waste from incineration: (Divide the change in volume, Item 4-b, by the volume before incineration, Item 1-d, and multiply by 100.) ______

# PLASTIC POLYMERS

**Subjects:** Chemistry, physics, physical science, science

**Format:** Teams of students, individual investigation, teacher demonstration

**OBJECTIVE:** To examine the chemical and physical properties of four common types of plastic and to illustrate why they do not biodegrade readily.

**METHOD:** Students conduct a series of tests on different types of plastic to determine their properties.

**BACKGROUND:** The first completely synthetic plastic was patented in 1907. Since that time, the use of plastics has grown to include an incredible variety of applications involving everything from astroturf to artificial hearts.

Plastics are formed into long chains, or polymers, by linking together short chains of micromolecules, or monomers. The durability that results from this linking not only makes synthetic materials very useful, but also makes them very difficult for natural systems to recycle. Our lives depend on the ability of bacteria, fungi, and other microorganisms to break down natural polymers, such as wood, cotton, and dead organisms, so that the resulting monomers can be used as the building blocks for other life forms. This is where plastic polymers become a problem. Plastic polymers do not readily decompose under natural conditions. Their chemicals are locked out of the life cycles, effectively removing a natural resource from the environment.

In addition, plastics can become a hazard to wildlife that mistake them for food, such as turtles do when they eat plastic bags that they mistake for jellyfish, or get tangled in them, as in the case of birds that get caught in discarded six-pack rings.

Finally, like all other forms of garbage, plastics consume valuable space in our nation's landfills, thus augmenting the solid waste problem. According to U.S. EPA, 20% (by volume) of the waste discarded in landfills nationwide is plastic.

**MATERIALS:** You will need the following:

- Polyethylene terephthalate (#1 plastic: 2-liter soft drink bottles, body portion only)
- High density polyethylene (#2 plastic: gallon jugs for milk, cider, or distilled water; base cups of 2-liter soft drink bottles)
- Polyvinyl chloride (#3 plastic: Saran wrap, imported mineral water bottles, plastic drain pipe)
- Polystyrene (#6 plastic: foam coffee cups, plastic picnic cutlery, foam packing "peanuts," egg cartons)
- Acetone (available at a local hardware store); a half pint or a pint will be plenty (you will be filling a Petri dish three-quarters full of acetone)
- Fireproof pan (aluminum or glass)
- A Petri dish
- Sixteen 250 ml Pyrex beakers
- Bunsen burner
- Tweezers

**WARNING:** Read through the "Plastic Polymers Warning" material that follows here before conducting the activity: it contains information which you should know before proceeding. Some steps warrant special safety measures.

**PLASTIC POLYMERS WARNING:**

**1. Substance: Acetone**

**Description: Clear, colorless, volatile liquid with a mint-like odor and sweetish taste. Boiling Point: 133 F (56 C), Melting Point: -139 F (-95 C), Volatility: 100%, Evaporation Rate (Butyl Acetate=1) 6, Solubility in water: very soluble, odor threshold: 20 ppm, Vapor density: 2.0.**

**Dangerous fire hazard when exposed to heat or flame. Vapors are heavier than air and may travel some distance to a source of ignition and flash back. Vapor-air mixtures are explosive.**

**Firefighting media: Dry chemical, carbon dioxide, water spray or alcohol-resistant foam.**

For larger fires, use water spray, fog or alcohol-resistant foam.

**Health effects**: irritant if inhaled or absorbed by skin or eyes. Central nervous system depressant, esp. dangerous for persons with chronic respiratory or skin diseases. Alcohol may enhance the toxic effects.

**If inhaled**: vapor concentrations around 1000 ppm may cause slight irritation of the upper respiratory tract, temporarily. Higher exposures cause more severe symptoms. Remove from exposure area to fresh air immediately,keep person warm and at rest, and get immediate medical attention.

**If skin contact occurs**: mild irritant. After immediately removing contaminated clothes and shoes, wash affected area with soap and large amounts of water until no evidence of the chemical remains (15-20 minutes). Get medical attention immediately.

**If eye contact occurs**: slight irritation occurs if exposure is only 1000 ppm or less, but higher concentrations have caused more severe problems such as corneal epithelial and conjunctival injury. Liquid splashed in human eyes causes an immediate stinging sensation and, if washed promptly, damage only to the corneal epithelium characterized by microscopic gray dots and a foreign body sensation, which heals completely in 1-2 days.

Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains (15-20 min.). Get medical attention immediately.

**If ingestion occurs**: 10-20 milliliters have been tolerated with no ill effect. Acute exposure has caused severe symptoms such as diarrhea, nausea and vomiting. 200 milliliters has caused stupor within a half hour. First aid - if the person is conscious and not convulsing, induce emesis (vomiting) by giving syrup of ipecac followed by water. If vomiting occurs, keep the head below the hips to prevent aspiration. Repeat in 20 minutes if not effective initially. Get medical attention immediately.

Warnings: Keep away from flame. Don't smoke in vicinity. Store away from incompatible substances. Provide explosion-proof ventilation equipment.

**Disposal**: dispose as a hazardous waste during special collections, or store in a clearly marked, tightly sealed container away from flames or heat until able to dispose of safely.

**2. Substance**: Polystyrene

Slight fire hazard when exposed to heat or flame. No other warnings apply.

**PROCEDURE:** Begin the activity by performing "The Disappearing Peanuts" trick for the students. (An alternative demonstration that does not use chemicals follows below in the "Grade-level Adjustments" section.) This demonstration consists of the following steps:

A. Partially fill a Petri dish with acetone (i.e., 3/4 full).

B. Cover the dish with a cardboard box with a small hole in its center.

C. Roll up both sleeves, drop polystyrene (styrofoam) "peanuts" into the hole, and pass your hands over the box with the aplomb of a venerable magician; continue dropping peanuts into the "magic hole."

D. Watch the reaction of the students as the box seems to take many more peanuts than it could hold.

E. Invite students to hypothesize on the cause of the peanuts' disappearance.

F. Then remove the box and conduct the demonstration a second time.

G. Once students have voiced their theories, discuss the concept of polymers. Note that the acetone breaks the bonds that hold together the various polystyrene polymer chains.

H. Then have students investigate other properties of plastics by conducting the following tests on each of the sample materials:

    1. Color test (to determine opacity and presence of pigmentation)
    2. Flex test (to determine texture and pliability)
    3. Float test (to estimate specific gravity)
    4. Acetone solubility test (WARNING: ACETONE IS FLAMMABLE -- **KEEP IT AWAY FROM FLAME**)
    5. Acid test (to determine resistance to strong acids)
    6. Alkaline test (to determine resistance to strong alkalies)
    7. Burn test (to determine how sample burns) -- **BURN UNDER A FUME HOOD**

I. The following are what students should discover from their tests:

1. **Polyethylene terephthalate (PET):**
    - a. Clear or colored; transparent
    - b. Smooth; highly resilient; hard to scratch
    - c. Sinks in water (specific gravity: 1.40)
    - d. Not soluble in acetone
    - e. Good resistance to strong acids
    - f. Poor resistance to strong alkalies
    - g. Gives off sweetly aromatic, irritating smell when burned
2. **High density polyethylene (HDPE):**
    - a. Clear or colored; opaque; matte finish
    - b. Textured; semi-rigid to flexible; does not crack when bent
    - c. Floats in water (specific gravity: 0.95)
    - d. Not soluble in acetone
    - e. Good resistance to strong acids
    - f. Good resistance to strong alkalies
    - g. Smells like a candle when burned
3. **Polyvinyl chloride (PVC):**
    - a. Clear or opaque
    - b. Smooth; forms white line when bent; scratches easily
    - c. Sinks in water (specific gravity: 1.30)
    - d. Not soluble in acetone

e. Good resistance to strong acids

f. Good resistance to strong alkalies

g. Burns with yellow flame; gives off acrid, hydrochloric acid smell when burned

4. **Polystyrene (PS):**

a. Clear or opaque

b. Smooth

c. Foamed PS floats (specific gravity: less than 1.00 (Note: the exact specific gravity depends on the extent to which the resin is foamed); unfoamed PS sinks (specific gravity: 1.05)

d. Very soluble in acetone

e. Good resistance to acid

f. Good resistance to alkalies

g. Burns with yellow flame, green near the base

**DISCUSSION/QUESTIONS:** Once students have charted the different properties of the four plastics, ask the following questions:

A. Why are there many different kinds of plastic in use? (One answer based on the chemistry of plastics is that different resins are suited to different uses, depending on their strength, flexibility, etc.)

B. Why do plastics have to be separated before they can be recycled? (One answer, again based on chemistry, is that different plastics have different melting points.)

C. Why don't plastics biodegrade? After all, they contain carbon like all organic materials. (One hypothesis on this subject runs as follows: since plastic polymers are synthetic and have existed on earth for such a short time, few if any organisms have developed enzymes that can break down their long polymer chains. Ask students how an organism might develop such a capability. How might this capability benefit the organism that develops it? This topic provides an effective means of initiating a discussion of Darwin's theory of evolution.)

D. Discuss the concept of "biodegradable" trash bags. Mention that they are made by splicing molecules of cellulose in between the regular polymer chains. Certain organisms possess the enzymes necessary to break down these cellulose molecules. When conditions are right, they can digest the cellulose, splitting up the synthetic polymer chains in the process. As a result, the trash bag breaks into little bits of non-biodegradable plastic. Ask students what the problems are with such an item. Will the bags biodegrade at all in a landfill? Test samples using the "Landfill in a Pop Bottle" activity to find out.

## FURTHER STUDY:

A. What effect does recycling have on a given polymer? Are reclaimed plastics recycled into higher order products that place greater demands on the feedstock, equivalent products, or lower order products that place less stringent demands on the feedstock? Why? Test some items made from recycled HDPE and compare the results to those for virgin HDPE. Do the two types behave similarly or differently in the tests? Note: samples of recycled HDPE can be obtained from the Plastic Lumber Company in Akron by calling (216) 762-8989.

B. Think of some everyday items made of plastic and the qualities that they ought to possess. Sample items might include car bumpers, cutting boards, ice cube trays, and laptop computer cases. Have students guess what kinds of plastic these items **might** be made from and then verify -- through product descriptions, manufacturer's specs, or other sources -- to learn from what they are actually made. Ask students to report their findings.

**VARIATIONS:** This activity can be adjusted to younger age groups by changing the opening demonstration and by reducing the number of subsequent tests performed. Replace the "Disappearing Peanuts" trick with a new exercise. This demonstration is entitled "Will It Leak?," and works as follows:

A. Fill a plastic sandwich bag with water.

B. Ask for a student volunteer who is brave enough to stand under the bag while you push a sharpened pencil through it.

C. Hold the bag over the volunteer's head. Jokingly tell the class that this event has never before been viewed on national television. Then slowly rotate the pencil in through one side of the plastic bag and out the other. No water should leak out. (Don't push it through completely.)

D. Have the volunteer then take the bag over to a sink and pull the pencil out to demonstrate that a trick bag was not used.

E. Ask students to hypothesize why the bag didn't leak when the pencil was pushed through.

F. If no one knows the answer, explain that plastics are made up of chains of polymers. As the pencil is pushed through the bag, it slips between these chains. Unbroken, the chains slide around the shape of the pencil, sealing in the water. A dull pencil, however, breaks the chains, and causes the bag to leak.

G. Now have students investigate other properties of plastics by testing for color, texture, flexibility, and specific gravity using the float test.

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## ACKNOWLEDGEMENTS:

Our thanks to Ben Hitchings for writing this activity.

# GETTING THE CAN TO THE COOLER

**Subjects:** Geography, earth science, environmental science, mathematics, economics, physics, chemistry

**Format:** Individual & group assignment; full class discussion; 1 class period, expandable as a week-long to school year-long investigation

COOLMAN
COOLER

**OBJECTIVE:** Students will (1) learn about how the availability of energy influences what products can be manufactured, (2) recognize the United States' current position as the highest consumer of nonrenewable resources, (3) learn what countries have the greatest reserves of selected resources, and (4) understand that decreases in resource reserves used for certain products can be due to population growth, creation of more demand for a product, and missed opportunities to reduce, reuse, or recycle certain resource materials.

**METHOD:** Students will examine what resources (raw materials) are used to manufacture certain products, what the geographic sources are of the raw material reserves, and how long certain resources are likely to last.

**BACKGROUND:** Resources are materials or forms of energy that can be used to make other materials. Resources include raw materials (e.g., sand), man-made materials (glass), and recycled material (cullet, or crushed glass ready to be re-manufactured).

Raw materials, such as iron ore or trees, are obtained from the natural environment: they are usually the starting ingredient for manufacturing products. Man-made materials, such as steel and lumber, are raw materials or recycled materials that have been processed or otherwise altered so that they are no longer in their natural state. For example, above, glass bottles can be made by mixing and heating sand, soda, and lime (raw materials are the source) or from melting and reforming cullet (crushed, used glass is the source).

Resources used by humans can be classified as **renewable** and **nonrenewable**. The former are those which can be replaced over and over again, such as trees through replanting. The latter are those of which we have a finite supply and can never be replaced, such as iron ore and oil. Renewable resources, such as water and trees, can last indefinitely if we take care of the "systems" that sustain them -- i.e., water sources need to be protected from physical depletion or obstructions so that they will be available in a usable form for hydropower, for example; trees must have their life requirements met -- nurturing soil, stable climatic conditions to which species have adapted, adequate carbon dioxide and water to perform photosynthesis, and conditions that foster reproduction of new trees. Non-renewable resources are limited in their supply, although probably we will never "run out" of oil or bauxite entirely. But the economic costs of extracting them will be so great that it will actually be tantamount to running out: at some point extracting the raw material from where it naturally resides costs more than the extracted material is worth.

As a result of manufacturing advances, increased consumer demand, overall population growth, and a lack in many of the world's people of an ethic of "stewardship" toward the raw materials that we all hold in common on earth, the consumption of nonrenewable resources has steadily increased over the past forty years. If current trends continue, global supplies of many nonrenewable resources, including aluminum, iron ore, lead, tin, natural gas, oil, and uranium, will be economically depleted within the next century.

Potential desirable strategies for extending the life expectancy of nonrenewable resources include:

* Using recycled materials rather than raw materials in the manufacturing process whenever possible;

* Substituting products made from renewable resources for products made from nonrenewable resources;

* Having consumers examine the necessity for their resource use and reduce it wherever possible.

A less desirable strategy is the development of new technologies for extending the life expectancy of nonrenewable resources, e.g., such as developing new technologies to obtain and use supplies of resources that are currently difficult and/or expensive to acquire. This might include drilling for oil or other extracted materials in natural parks or fragile ecosystems. Many people believe this is not a reasonable choice because the cost to the environment in both cases exceeds the benefit of the small amount of extracted material realized.

## MATERIALS:

- Glass, paper, plastic, aluminum, and a tinned can
- Transparencies on each manufacturing process -- glass, paper, plastic, aluminum, and tinned cans (see end of the activity)
- The "Energy and Resources" student worksheet; and the "Energy and Resources" teacher reference sheet
- (Optional) Ring stand, scales, water, candle, thermometer, pan, matches, and water to demonstrate increasing water temperature by 1°

## PROCEDURE:

A. Review the raw materials and processes used in the manufacture of glass, paper, plastic, aluminum, and a tinned can by displaying the transparencies.

B. Hand out copies of the "Energy and Resources" student worksheet. Review the Table in Part 1. Explain that one Btu, British thermal unit, is the amount of heat needed to raise the temperature of one pound of water by one degree Fahrenheit.

Optional: Ask the students to demonstrate this by weighing a pan, adding water to make the total water weigh 1 pound or two pounds. Weigh the candle. Then heat the water with a candle on the ring stand until the temperature rises 1°. Weigh the candle to learn the cost of converting the energy in wax to a temperature change in water.

## DISCUSSION/QUESTIONS:

Ask the students to refer to the worksheet and respond to the following questions:

A. Which manufacturing processes are more energy intensive?

B. Which manufacturing processes are less energy intensive?

C. What are the Btu requirements for manufacturing each product when recycled materials are used in place of raw materials?

D. What product saves the most energy when recycled materials are used for manufacture?

E. What product saves the least energy when recycled materials are used for manufacture?

F. What happens to the energy in these products when they are thrown away? Burned? Recycled?

G. Ask students to answer questions 1 and 2 on the worksheet. Ask them to define the term "resource," review the difference between a renewable resource and a nonrenewable resource, and provide examples of each. Then ask the following questions:

1. What clothing materials come from renewable resources? Nonrenewable resources?

2. What packaging materials come from renewable resources? Nonrenewable resources?

H. Review the table in Part 2 of the worksheet. Explain that the resources used to manufacture many products are nonrenewable, in limited supply, and are not found in the U. S. Conduct a whole class discussion addressing the following questions:

3. What is static use?

4. Why are projected rates of use greater than static rates of use?

5. Is the actual use of these materials static or increasing at the projected rates?

6. What influence does an increase in human population have on the rate of use of resources?

7. What resources are not found in the United States?

8. What country or area(s) has the greatest overall reserves of these resources?

9. What is the U. S.'s present relationship with some of the countries which contain these resources?

10. Why is dependence on other countries for resources sometimes a problem?

11. How can we as individuals help stem the depletion of nonrenewable resources?

List the student's ideas on the board or on an overhead.

I. Ask students to answer Questions 3 and 4 on the worksheet. Tell students that our earth is so rich in resources that some people say there actually may be plenty of resources available -- but for a price. That price may be using even more energy, more equipment, contributing to even greater environmental degradation to get less easily obtained resources from the earth.

Ask students to identify the pros and cons of finding and obtaining these resources.

## FURTHER STUDY:

A. Assign students to research the potential for mining minerals beneath the oceans. Who "owns" these minerals?

B. Assign students to come up with substitutes for resource materials that are in short supply. Ask them to identify what characteristics substitutes would have to have to replace aluminum, iron ore, lead, plastics, paper, and tin.

C. Ask students to research the pros and cons of proposed drilling for oil in the Alaska Wildlife Refuge and then present a pro and con presentation to the class.

## ACKNOWLEDGEMENTS:

Our thanks to the Florida State Department of Education for permission to reproduce/adapt this activity from its "Running Out of Resources" activity in its *4 Rs Project*.

# "Energy and Resources" Student Worksheet

| Energy requirements using *raw materials* for manufacture: | |
|---|---|
| Paper | 20.373 Btu/lb |
| Glass | 7.611 Btu/lb |
| Steel | 14.778 Btu/lb |
| Aluminum | 98.560 Btu/lb |
| Plastic | 18.532 Btu/lb |

| Energy savings using *recycled materials* for manufacture: | |
|---|---|
| Paper | 30-55% |
| Glass | 8-32% |
| Steel | 47-74% |
| Aluminum | 95% |
| Plastic | 60-70% |

1. Which industries will be hard hit in the next energy crisis? Why? ____________

____________

2. In what two ways would the plastics industry be affected if oil prices rose sharply?

____________

Part 2

## NONRENEWABLE NATURAL RESOURCES:

### Life Expectancies and Prime Consumers

| Resource | Reserve Base | Countries or Areas with Highest Reserves | Prime Consumers | Life Expectancy in Years | |
|---|---|---|---|---|---|
| | | | | STATIC USE at current level | USE growing at projected rates |
| Aluminum in Bauxite | 23.2 billion metric tons<br>metric ton= 2.200 lbs. | Guinea 25%<br>Australia 20%<br>Brazil 13%<br>Jamaica 9% | USA 42%<br>USSR 12% | 312 years | 63 years |
| Iron in Ore | 98 billion short tons<br>short ton= 2.000 lbs. | USSR 26%<br>Australia 21%<br>Brazil 11%<br>Canada 10%<br>S.Africa 7%<br>USA 6% | USA 28%<br>USSR 24%<br>West Germany 7% | 172 years | 62 years |
| Lead | 142 million metric tons | Australia 20%<br>USA 12%<br>Canada 10% | USA 25%<br>USSR 13%<br>West Germany 11% | 37 years | 25 years |
| Tin | 4.2 million metric tons | Malaysia 26%<br>Indonesia 16%<br>Brazil 15%<br>China 9% | USA 24%<br>Japan 14% | 41 years | 31 years |

3. List the prime consumer of each resource. Aluminum: ____________

Iron Ore: ____________ Lead: ____________ Tin: ____________

4. If consumption grows at projected rates, which resource will be the first to be depleted? Next? List in order. Next to these, list how old you will be when the resource is depleted.

1. ____________ 2. ____________

3. ____________ 4. ____________

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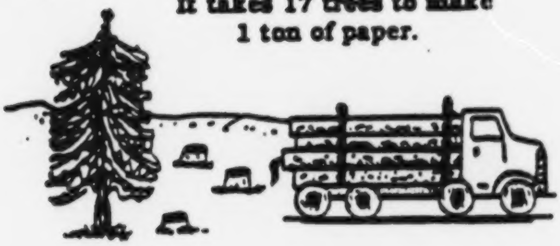
# PAPER MANUFACTURING

①

**It takes 17 trees to make 1 ton of paper.**



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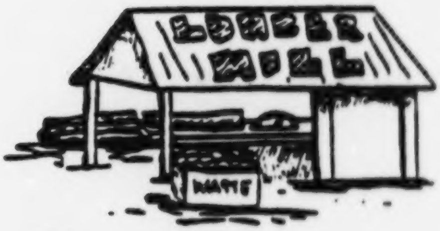

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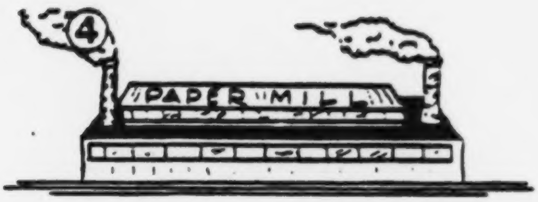

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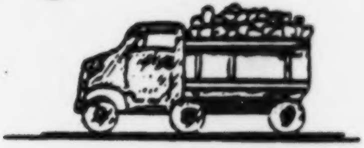
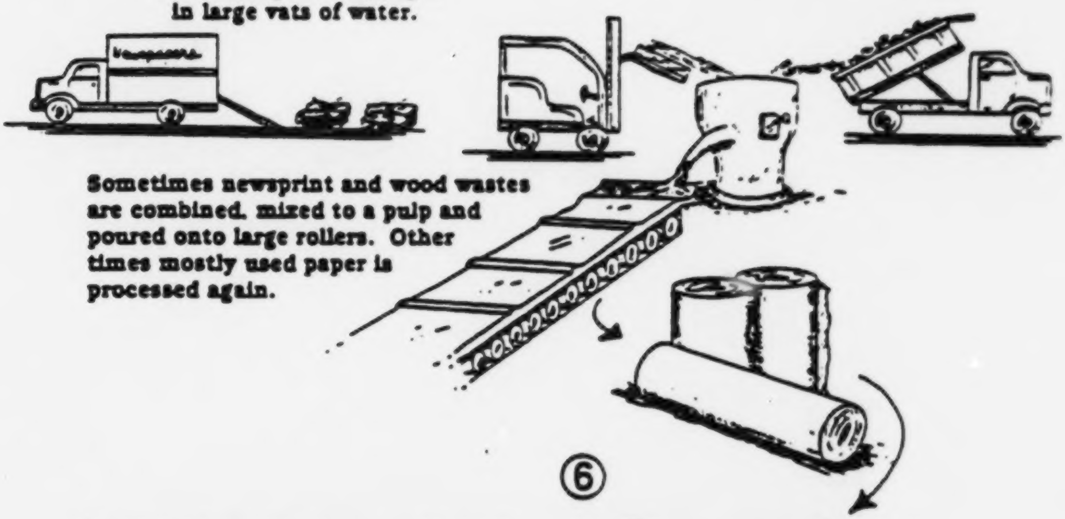


**Wood waste from lumber yards is recycled to make paper.**

⑤ **Old newsprint is de-inked by washing and rinsing it in large vats of water.**



**Sometimes newsprint and wood wastes are combined, mixed to a pulp and poured onto large rollers. Other times mostly used paper is processed again.**

⑥

**The rolls of new paper are used to make newspapers, drawing paper, computer paper and many other kinds of paper.**

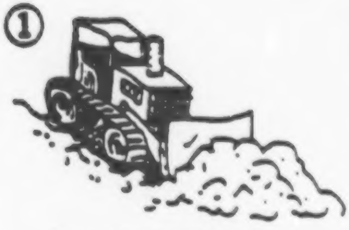
NEWS
DRAWING PAPER

Artwork from the Florida Department of Education's "Running Out of Resources" activity in its *4 Rs Project*.

BEST COPY AVAILABLE

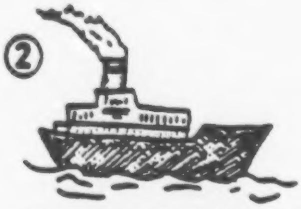
# ALUMINUM CAN MANUFACTURING

①



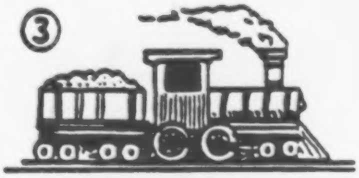
Bauxite is mined . . .

②



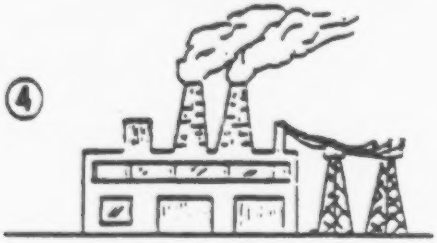
shipped to the U.S. and . . .

③



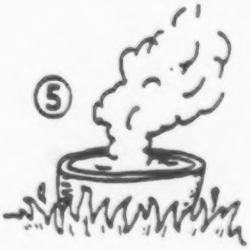
transported to factories.

④



Electrolysis separates the aluminum from bauxite.

⑤



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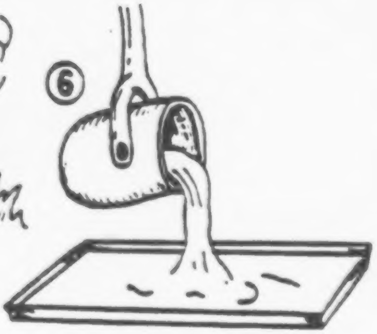
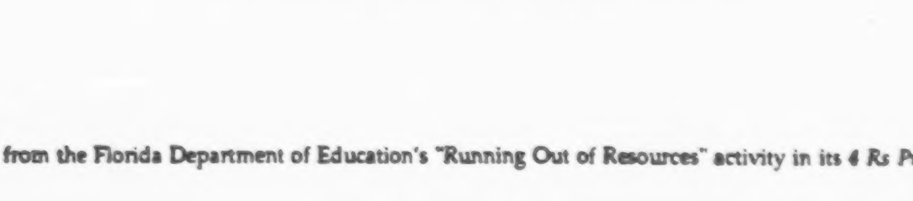


Aluminum is poured into flat sheets and later . . .

⑦

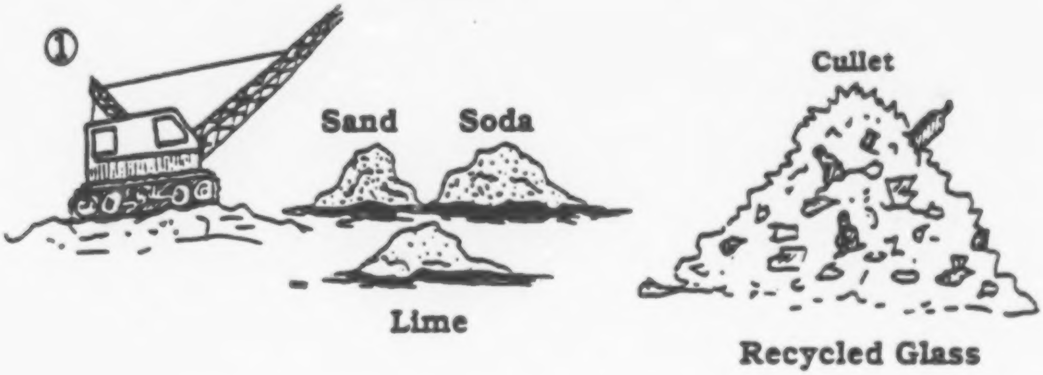


. . . shaped into cans.

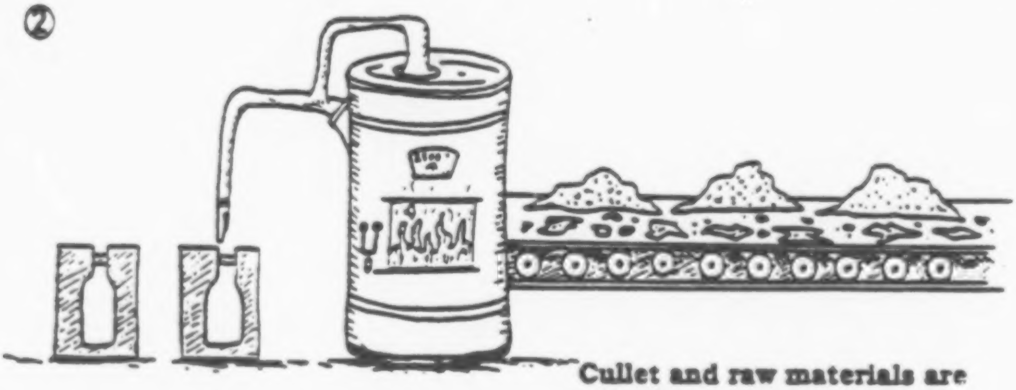
Artwork from the Florida Department of Education's "Running Out of Resources" activity in its *4 Rs Project*.

# GLASS MANUFACTURING

①

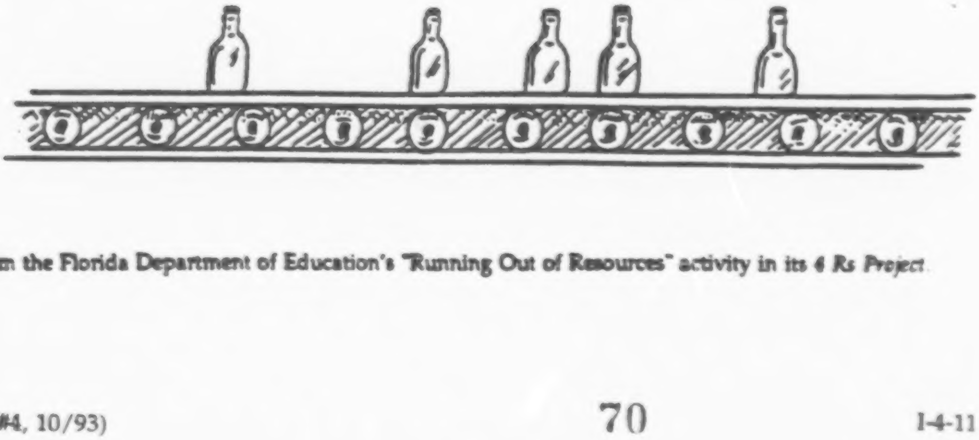

Sand
Soda
Lime
Cullet
Recycled Glass

②



Cullet and raw materials are melted together. The melted mixture is poured into molds and injected with air. The mold is removed and the glass is cooled and shipped.

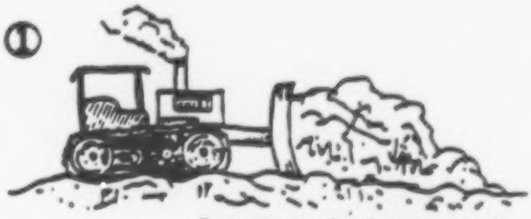
③



Artwork from the Florida Department of Education's "Running Out of Resources" activity in its *4 Rs Project*.

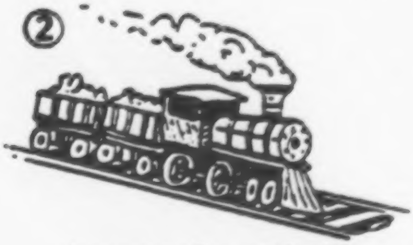
# TINNED CAN MANUFACTURING

①



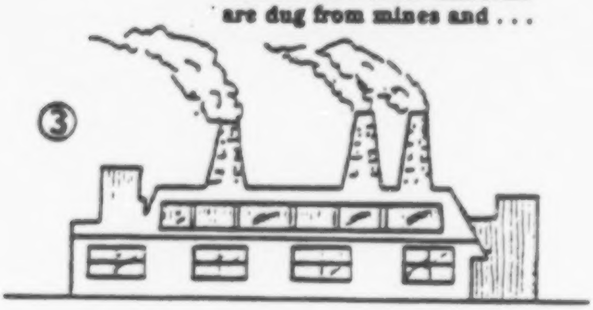
**Iron ore and other minerals are dug from mines and . . .**

②



**transported to steel mills.**

③



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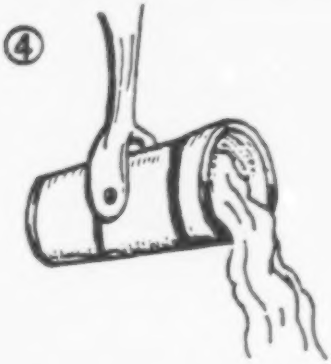
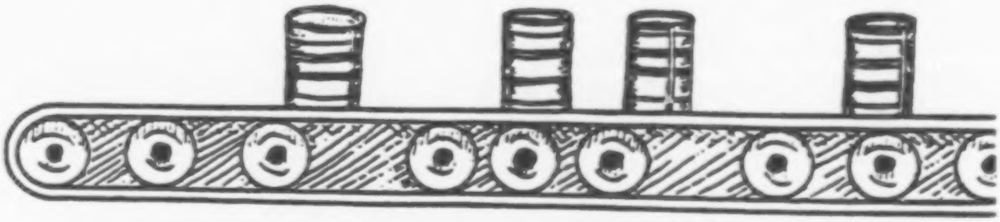


**The minerals are heated in large vats and poured onto sheets.**

⑤

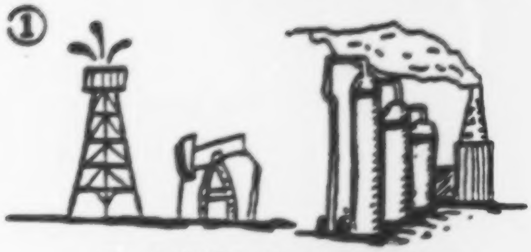


**The steel is coated with tin and shaped into cans.**

Artwork from the Florida Department of Education's "Running Out of Resources" activity in its *4 Rs Project*.

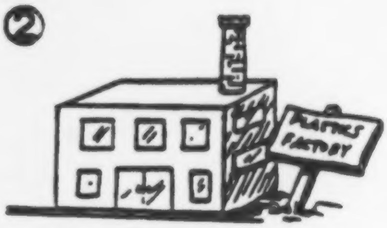
# PLASTIC MANUFACTURING

①



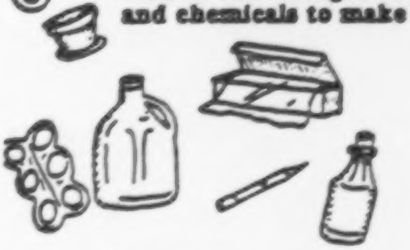
**Fuels (oil) and natural gas are refined and changed with heat and chemicals to make resins.**

②

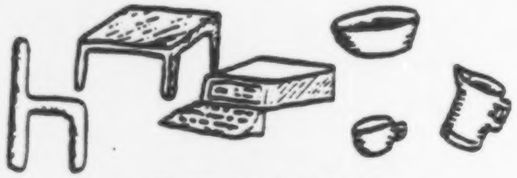

PLASTICS FACTORY

**Resins make . . .**

③

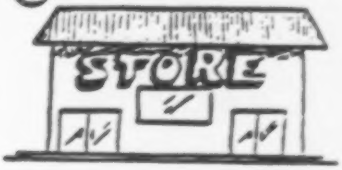


**Thermoplastics**



**Thermoset plastics (permanently shaped)**

④



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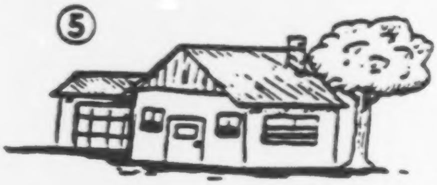

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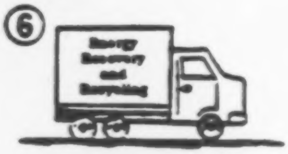
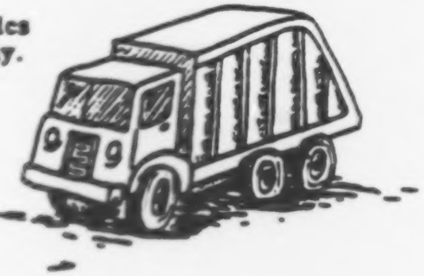
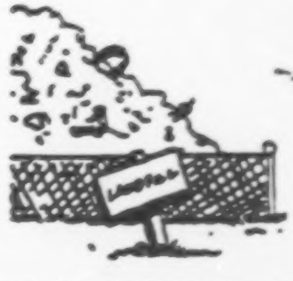

Energy
Recovery
and
Recycling

**Some plastics are taken to recycling centers and others are burned to recover their energy.**

⑦ **99% of all plastics are thrown away.**





Artwork from the Florida Department of Education's "Running Out of Resources" activity in its *4 Rs Project*.

# MODEL CITY RELAY

**Subjects:** Science, social studies, physical education

**Format:** Teams of students outdoors

WHY?
How?
WHERE?

**OBJECTIVE:** To demonstrate that disposing of waste requires energy that can be saved by removing reusable and recyclable materials from the waste stream. Students will (1) learn that recycling saves energy, (2) plan a simple waste disposal strategy, and (3) learn what can be recycled.

**METHOD:** Students will be assigned to "City" teams to compete with each other outdoors for a "Model City" award for their planning and recycling efforts.

**BACKGROUND:** More than half of the cost of waste disposal goes for hauling waste. Recycling saves energy in reduced hauling costs. And it lowers production costs by using remanufactured materials. It also reduces water, soil, and air pollution.

In Cuyahoga County, Ohio, for example, tipping fees alone are now (1991) around $35 per ton, as compared to 1980 and 1983 when they were less than $10 and $20, respectively. The 1993 projected tipping fees are approximately $55 per ton. (Source: Cuyahoga County Planning Commission, Bechtel, Inc.) These fees are expected to increase indefinitely.

The teacher should be ready to explain to students which items can be recycled and reused.

## MATERIALS:

- One pile of 20 to 30 pieces of unsorted garbage for each team

- One container for recyclables
- One container for reusables
- One large container to serve as a landfill
- Model City Award certificates

## PRE-ACTIVITY QUESTIONS:

A. Can you name three items that can be recycled?

B. Can you name two reusable items you have at home?

C. When we put waste into a garbage can, where is it taken for disposal?

## PROCEDURE:

A. Form teams of four or five students each. Explain that each team represents a community group competing for the coveted Model City Award Certificate. This award will be presented to the first team able to deal effectively with its waste. Copy the enclosed award.

B. Set up the recycling and reuse receptacles approximately 20 feet from the starting line. Locate the large receptacle representing the landfill as far away on the playground as is reasonably possible.

C. Before beginning the contest, review different ways we can deal with waste.

Ask students: How does garbage get to a landfill?" "What costs are involved in getting garbage to a landfill? What reasons would communities have for locating their
landfill as far away as possible?

D. Make sure each team has a waste pile containing an equal number of recyclable or reusable items among the unrecyclable and unreusable items.

E. Explain the rules of the game: This is a modified relay race in which only one person at a time from each team can put something in one of the containers and only one item at a time can be deposited. Each group should plan how it will deal with its waste in the least time, and in the most energy-efficient way.

Give each group several minutes to plan its waste disposal strategy, then start the game.

F. Monitor students' disposal choices to confirm students' claims about whether materials are recyclable. (Students may also monitor.)

**DISCUSSION/QUESTIONS:** When the last team finishes dealing with its waste, gather everyone together and have a follow-up discussion.

A. Ask the students what methods of waste disposal did the winning team use (e.g. Team members recycled and reused materials to the greatest extent possible; team members continually sorted rather than waiting to sort before each run; team members invested more energy in waste disposal by running faster, etc.)?

Generate and rank/order a list of ways time and energy were used in dealing with the waste: sorting, running to the recycling receptacles, running to the landfill, etc.

B. In what other ways is energy tied up in waste? (Answer: in the derivation of the raw materials and in the manufacturing and transportation of products and packaging that become waste.)

C. What does our town and county do with our waste? What have we learned from this game that might help our town and county better manage our waste?

D. Present the Model City Award Certificate to the winning team.

## FURTHER STUDY:

A. Call your County Planning Commission's Recycling Coordinator to find out the location of your nearest recycling center.

B. Visit a nearby recycling center in your community.

C. Invite a community recycling coordinator to speak to your class.

# SOURCES:

"Go Grime Busters," *National Geographic World.*" August 1989, pp. 29-30.

Pollack-Shea, Cynthia. "Realizing Recycling's Potential," *State of the World 1987.* New York, N.Y.: W.W. Norton & Company, 1987.

# ACKNOWLEDGEMENT:

Our thanks to the Washington State Department of Ecology for its permission to use this activity from its publication, *A-Way with Waste.*

# MODEL CITIES RELAY CERTIFICATE

*Congratulations to:*

____________________________________

*Relay Winner*

____________________

*Date*

*Signed*____________________

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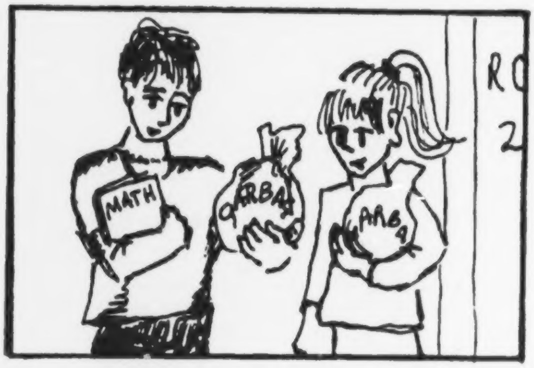
# PERFORMING A SCHOOL WASTE AUDIT

**Subjects:** Social studies, mathematics, science, environmental science, home economics

**Format:** Teacher directed activity carried out over approximately a week but totalling 1 - 3 periods, at teacher's option; some Options, e.g., B, C, & D can also be done by individual or student teams who will report their findings



**OBJECTIVE:** (1) To introduce students to the concept that garbage does not simply disappear once it is collected, (2) to teach students about the components of the waste stream and their relative quantities, and (3) to have students analyze the waste from their classroom, lunchroom, or entire school building.

**METHOD:** One or several of 4 options:

Option A - have teacher in classroom save trash for one week without informing students

Option B - have each student collect his or her trash and carry it around for one week

Option C - have students conduct one-day audit of classroom or food service waste

Option D - have students examine contents of school dumpsters and analyze them

**BACKGROUND:** For too long, Americans have been able to put their waste on the curb and watch it disappear when refuse trucks pick it up and carry it off. There is little knowledge about where it goes or what happens to it once it gets where it is going. There has also been little incentive to conserve, generate less waste, and monitor the hazards of waste that has been discarded. For example, we have carelessly thrown away hazardous materials such as lead-based paint, motor oil, nail polish remover, and oven cleaner without realizing the potential threat to the groundwater these materials pose when dumped in landfills with inadequate safety features: they can leak into groundwater. Such groundwater contamination threatens the safety of many of this country's drinking water sources. (See the "Landfill in a Pop Bottle" activity for an explanation of this problem.)

In addition, Americans have become a "disposable society." Products that used to be manufactured to last a lifetime are now designed to be thrown away after only one use. Convenience is touted as being the most important quality of many products, even of dangerous, hazardous, or toxic products which harm the environment. For example, now there are even disposable cameras.

How aware are we of the waste we generate? Studies have been done to analyze both the contents of the national waste stream and the waste streams of schools. Paper makes up the largest component of schools' waste streams. (See charts on national and school waste streams at the end of this activity). Students will learn what the other components of the waste stream are as well.

Students will also experience just what kind of waste they are generating. Each American throws away about 3-to-4 pounds of waste per day. Students produce about a half pound of waste per school day. All of this adds up to a problem because America's old landfills are filling up quickly and leaking hazardous chemicals into the groundwater, and new, safer landfills are very costly to construct.

## PRE-ACTIVITY QUESTIONS:

A. How much waste do you think you generate in one school day? In one whole day? (Record students' estimates and then compare them with the actual figures.)

B. How aware are you of the waste you throw away? What do you throw away in a given day?

C. Why is such waste produced? Is it necessary?

## MATERIALS:

- The waste generated in classrooms and food service areas
- Plastic garbage bags for students to contain their wastes
- A scale for weighing materials

- Washable plastic tarp
- Gloves and goggles for dumpster audits
- "Selected Component % in Total Waste Stream by Producers" handout (end of activity)
- Permission Slip (end of activity)

## PROCEDURE:

Option A: Without telling the students, save the trash generated in the classroom for one week. You may want to enlist the maintenance person's help, so that either he/she will know that you are not going to need your trash picked up for a week; possibly he/she could pick it up as usual but save it for you somewhere away from the classroom.

Then ask the students how much waste they think the class would generate in a week, and write the guesses (in numbers of bags and pounds) on the board. Bring in the actual amount generated and discuss how it compares with the guesses.

Option B: Have each student bring a garbage bag to school on Monday. Inform students they must carry with them in that bag any trash that they generate during the week. (NOTE: You will need to set ground rules for: (1) Whether students are to add the materials they generate at home as well, necessitating that they take their garbage bags to and from school daily; (2) If you are including food waste, be sure that students do not store the bags in lockers or other areas where vermin, cats, dogs, or other animals might be attracted to the contents; (3) Suggest double or triple bagging to prevent tearing and spilling.)

At the end of the week, have students weigh their bags of garbage to see how much they generated. Ask them to classify how much was paper, how much was food waste, etc. (They don't have to weigh these individual components -- just estimate them.)

Option C: Have students collect all the waste that they make in one day in the classroom and put it someplace so that the maintenance staff does not throw it away. The next day, have students analyze what they generated: what percent was paper? aluminum? food wrapping? organic material? What could have been recycled? In what ways could they generate less?

Coordinate with Food Service staff to have students collect waste from the cafeteria at one lunch period. Have two types of clearly marked containers wherever trash cans are located: one for food refuse and one for non-food refuse. Make sure that this is announced to the students eating lunch both at the beginning and towards the end of the lunch period - explain what you are doing and why you are doing it. Weigh the food waste and the non-food waste generated; then, go through the non-food waste to determine how much of it could have been recycled.

Option D: Get permission from parents and principals to have students examine the contents of school dumpsters. (See sample permission slip at the end of the activity.) Provide them with safety goggles and heavy gloves. Spread out a washable plastic tarp and have students dump the contents of garbage bags from the dumpster onto the tarp. Sort it into categories: paper, plastic, metal, organic, recyclable, nonrecyclable. Chart your results and compare them with the national average for the components of a school waste stream (a chart of national data follows this activity).

## DISCUSSION/QUESTIONS:

A. What percent was paper? Aluminum? Food wrapping? Organic material? Other? (specify)

B. What materials are recyclable? What materials can be recycled in your city?

C. What materials that were thrown away could have been recycled?

D. In what ways could students and staff create less waste?

E. What effect did carrying their waste around for a week have on students? (For example, were they surprised by the weight and volume of the waste they collected? Did it lead them to think more actively of ways to reduce waste? What if everyone had to carry their waste around with them all the time? Would we make less or encourage manufacturers to change the design of products (e.g., virtually nonrecyclable aseptic drink boxes) or modify our purchasing habits? These are topics that can be addressed to students for their evaluation.

**FURTHER STUDY:** Plan ways to implement a food waste collection/composting program in the school. What containers would be needed? What education of students would be required? What kind of signs? Where could materials be composted? Draw up a plan that includes doing a search for useful literature (e.g., *Recycling Today, Resource Recycling, BioCycle,* for example), contacts with the school administration, the local county extension service, the county planning commission, the municipality, etc. to discuss the requirements for a composting site.

## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for writing this activity.

## Selected Component % in Total Waste Stream by Producers*

| **Component** | **Educational Institutions** | **Offices (Busi/Lgl)** | **Gov't Offices** | **Retail & Whlsle** |
|---|---|---|---|---|
| Nonrecyclable glass | 2.2% | 1.0% | .3% | .2% |
| Aluminum cans | .8% | 5.0% | .5% | .2% |
| Aluminum containers | .6% | - | .3% | .2% |
| Ferrous metals | 3.0% | .9% | 2.2% | 14.6% |
| Other metals | .5% | - | - | .4% |
| Newsprint | 3.3% | 3.6% | 6.7% | 2.9% |
| Corrugated paper | 11.6% | 11.5% | 8.4% | 22.0% |
| Mixed/Scrap paper | 21.6% | 29.0% | 25.0% | 10.3% |
| Computer paper | 1.9% | 3.8% | 3.1% | 1.0% |
| Nonrecyclable paper | 5.0% | 9.5% | 6.5% | 4.9% |
| PET bottles | .1% | .1% | .1% | .1% |
| HDPE bottles | - | - | - | - |
| Plastic packaging | 4.2% | 3.2% | 2.5% | 7.9% |
| Expanded polystyrene | .5% | .6% | .2% | .6% |
| Rubber products | .6% | - | .2% | .9% |
| Tires | 1.3% | - | 1.2% | - |
| Food | 14.0% | 3.0% | 3.2% | 8.1% |
| Yard & garden waste | 17.5% | 2.5% | 7.8% | 1.1% |
| Wood | 3.5% | 5.3% | 12.2% | 9.6% |

SOURCE: R. W. Beck & Assoc., May 1989 *Achieving Optimal Waste Recycling and Source Reduction: Methods to Reach Your County's Recycling Goals* FROM *How to Implement a Plastics Recycling Program*. *Totals do not equal 100%.

## PERMISSION SLIP

On (date) ________________ your daughter or son will be participating in a study of waste generated by __________________________ School. This will involve the handling of school waste from dumpsters. Students will be provided with heavy gloves and goggles, we will coach them in safety procedures, and every precaution will be taken to ensure your child's safety. A faculty member will be present. We need your permission for your child to participate in this activity. If this meets with your approval, please sign the statement below, detach it, and return it to us by (date) _______________.

If you have any questions, please contact ______________________ at ___________________ School at (telephone #) _________.

Sincerely,

My child, __________________________ has my permission to participate in the school waste audit to be conducted at ____________________ School.

______________________________ (parent's signature)

________________________ (date)

# PART I

## EVERYTHING ENDS UP SOMEWHERE

- *Alternatives to Incineration and Landfilling*

# MAKING RECYCLED PAPER BY HAND

**Subjects:** Art, environmental science, science

**Format:** One class period or more, depending on teacher's goals for students

**OBJECTIVE:** To teach students about the paper-recycling process.

**METHOD:** Students review the various steps involved in recycling wastepaper and then perform some of the procedures themselves by making their own recycled paper in the classroom.

**BACKGROUND:** Papermaking is an ancient art. The technique was invented in China in 105 A.D. Kept secret for many centuries, the process did not arrive in Europe until the 12th century. The first papermaking mill in the American colonies was established in Germantown, Pennsylvania, in 1690.

Paper consists of many tiny fibers that are connected by a bond that is activated by water. These fibers can come from many different sources -- wood and plant fiber, cloth, and other materials etc.

Workers in colonial America fed their mills with old rags. No longer useful as clothing, cotton and linen fabric contained an abundance of plant fiber ideal for papermaking. Rags continued to provide the major source of paper fiber in the United States until the mid nineteenth century, when the supply of old clothing could no longer keep up with the demand for new paper. As a result, scientists developed an alternative method that used the cellulose fiber from trees. Wood pulp has been the major source of fiber for paper ever since.

Just as scientists worked to develop a new source of paper fiber, we too must now alter our habits in order to address the growing solid waste problem. Throughout the country, our disposable ways are overburdening our ability to handle waste safely. The landfills that take most of our garbage are rapidly reaching capacity. Likewise, our ever-increasing demand for paper and wood products is depleting our valuable timber reserves faster than we can renew them. Recycling is one effective way to address both of these problems. Making recycled paper not only teaches us about the recycling process, but also it's a lot of fun.

## MATERIALS:

- Two coffee cans (one 2 lb. size and one 1 lb. size)
- A can opener
- Two pieces of window screen (7" x 7") and one piece of hardware cloth (also 7" x 7"), which is heavy duty screen with holes larger than conventional door and window screening each)
- A plastic dishpan (large enough to hold 2 lb. coffee can)
- Assorted pieces of colored scrap paper from the classroom
- Scissors
- An electric blender
- A large spoon
- Several kitchen sponges
- Several clean rags or towels
- Thread and leaves
- A small stack of newspaper
- A rolling pin
- A clothes iron (optional)
- Microscope

- Magnifying glass
- "Making Recycled Paper by Hand" diagram

Teachers may want to pre-assemble several sets of the above materials so that more students can participate at the same time.

**PROCEDURE:** The following is a simple way to make paper in the classroom. For more sophisticated methods, see chapters 4 - 10 in Arnold E. Grummer's book *Paper by Kids*, as well as other references listed below in the **SOURCES** section.

Ask your students to perform the following 4 steps:

**STEP 1: Making the Mold and Deckle**

A. Place the 2 lb. coffee can in the plastic tub (see diagram at the end of the activity).

B. Lay the sheet of hardware cloth on the top of the 2 lb. can.

C. Lay one 7" x 7" piece of window screen on top of the hardware cloth. This apparatus is your **mold**.

D. With the can opener cut the bottom off the 1 lb. coffee can. It should now be open at both ends. This can serves as the **deckle** (i.e., the frame that forms the sides of the sheets of paper).

E. Now place the 1 lb. coffee can on top of the screen (see diagram at end of activity for a visual representation).

**STEP 2: Preparing the Wastepaper**

A. Fill the electric blender with just enough water to cover the blade.

B. Then drop pieces of cut up wastepaper into the blender and run the blender until the paper has been ground into an oatmeal-like consistency. (Students will have to experiment with amounts of paper, since different kinds of scrap paper will be heavier than others.) This mixture is called a **pulp slurry**.

**STEP 3: Pouring the Pulp**

A. Add more water to the blender until it is three quarters full.

B. Now have one student hold the deckle while another pours the contents of the blender over the screen. The water will drain into the 2-lb. coffee can and the paper fibers will catch on the screen.

C. Ask the student to continue to hold the deckle until all the water has drained through the screen. Then remove the deckle.

**STEP 4: Drying the Paper**

A. Lift off the screen containing the paper fibers and place it on a towel or on several sheets of newspaper.

B. Place the second piece of window screen on top of it.

C. Using a moist sponge, press the wet paper to blot up as much moisture as possible from the paper. Wring the sponge, blot, and wring again until the sponge no longer absorbs water.

D. Then, lift off the top screen and carefully place several folded sheets of newspaper on top of the wet paper.

E. Then use the rolling pin to squeeze out more water.

F. The paper should now be dry enough to remove from the screen. Using your fingernail, carefully peel off the sheet of paper and place it on a rag or towel. If the paper is not dry enough to remove, roll it some more with the rolling pin.

G. Let the paper dry overnight.

H. If students want to hasten the drying process, they can place the sheet of paper inside a towel and iron it. Make sure to warn students not to touch the hot iron.

## DISCUSSION/QUESTIONS: Ask students the following questions:

A. What do you see when you look at the paper under a microscope or through a magnifying glass?

After answers are offered, ask students to conduct the following experiment to learn about the properties of dry versus wet paper fibers:

1. Direct one student to hold a piece of dry tissue paper between his or her hands while another student places several quarters on top of it. What happens? Why?

2. Now wet the tissue paper slightly and repeat the experiment. What happens? Why?

B. Go over **THE PAPER RECYCLING PROCESS** sheet (included at the end of the activity) with students and have them equate the papermaking steps they used with those used by the paper mills themselves in paper manufacture.

C. What are the benefits of recycling paper?

## VARIATIONS:

A. Ask students to build their own mold and deckle out of wood. For information on how to do this, see the various references listed in the "Sources" section.

B. Assign students to try some of the paper variations described in chapters 6 - 8 of Arnold Grummer's book *Paper by Kids*. These include making decorative paper using thread, leaves, and dyes.

C. Ask students to experiment with different types (newspaper, copy paper, bond paper) and quantities of waste paper that they use. Then have them use the coin test described above to test each of their variations. Have students report on their results.

## FURTHER STUDY:

Pick another material such as aluminum or glass and research its recycling process.

## SOURCES:

Grummer, Arnold E. *Paper by Kids*. Minneapolis, MN: Dillon Press, Inc., 1980.
Powell, Jerry. "Hand Papermaking: Recycling Education at Its Best." *Resource Recycling*, (Jan./Feb. 1989), pp. 30-33 and 49.

Toale, Bernard. *The Art of Papermaking*. Worcester, MA: Davis Publications, 1983.

Weidenmuller, Ralf. *Papermaking: The Art and Craft of Handmade Paper.* Translated by John Kalish. San Diego, CA: Thorfinn International, 1984.

## ACKNOWLEDGEMENTS:

Much of the general information presented here is taken from Arnold Grummer's book *Paper by Kids.*

Our thanks to Ben Hitchings for writing this activity.

# THE PAPER RECYCLING PROCESS

## A. COLLECTION:

STEP 1 The recycling process begins with individuals who sort wastepaper into collection bins at home and at work.

STEP 2 The wastepaper is then transported to a local paper dealer or **re-processor**.

STEP 3 The re-processor grades the paper, bails it, and loads it into trucks for shipment to paper mills.

## B. RE-MANUFACTURING:

STEP 5 Upon arriving at the mill, the paper is dumped into a large machine called a **hydrapulper**. The hydrapulper uses water and mixing blades to break down the paper until it has the consistency of oatmeal. This substance is called a **pulp slurry**.

STEP 6 After leaving the hydrapulper, the slurry is forced through screens to clean out large contaminants such as staples and paper clips.

STEP 7 Then the slurry is run through a machine known as a **cyclone de-gritter** that removes smaller dirt particles.

STEP 8 Once the slurry has been cleaned of contaminants, the ink is removed using hot water and detergents.

STEP 9 This process draws much of the ink out of the paper fibers, but the slurry is still darker than virgin paper. As a result, most mills bleach it to make it lighter. This is one of the most potentially harmful stages of the papermaking process because of the dangerous chemicals that are often used (e.g., chlorine bleach, which is associated with generating a harmful chemical called "dioxin.") However, because the paper fibers have already been treated once before, the recycled slurry does not have to be bleached as much as virgin wood pulp, thereby reducing the amount of chemical waste that is generated.

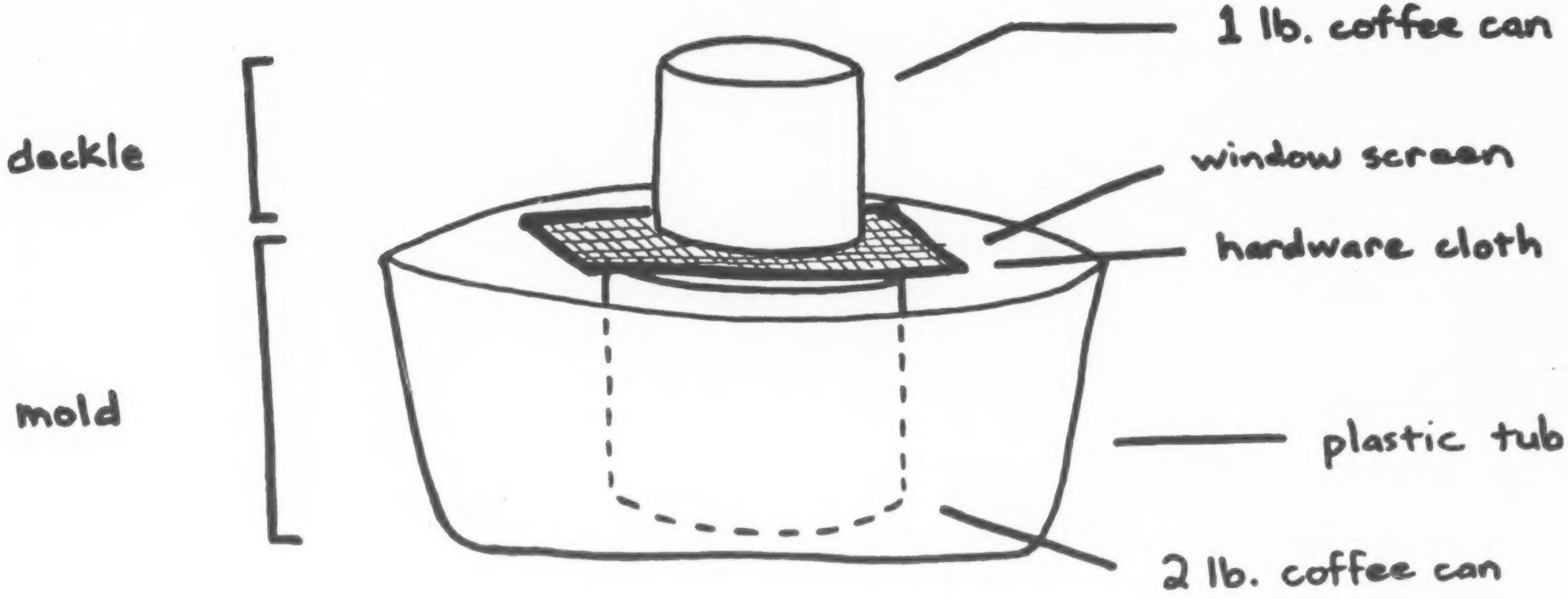
STEP 10 Following this cleaning and bleaching procedure, the recycled pulp is mixed with virgin fibers and fed onto a rotating screen where it is pressed into new paper, dried, and then shipped to wholesalers.

**RE-SALE:**

STEP 11 The last step in the recycling process is the sale of recycled paper to consumers like you and me who will use the paper again, and then recycle it once more.

**NOTE:** As paper is recycled again and again, the fibers become shorter. Long fibers are found in higher grades of paper -- photocopy bond and stationery, for example -- while short fibers are found in lower grades, such as pressboard egg cartons, paper towels, and cardboard. Therefore, to extend the life of shortened recycled paper fibers and to get higher grades of paper, some virgin fibers are added to recycled paper pulp.

## MAKING RECYCLED PAPER BY HAND


1 lb. coffee can
deckle
window screen
hardware cloth
mold
plastic tub
2 lb. coffee can

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# SEPARATION MANIA

**Subjects:** Science, mathematics,

**Format:** A series of activities to classify and separate waste by the most efficient means possible

SINKER OR FLOATER?

**OBJECTIVE:** Students will be able to (1) describe the function of various separation techniques in recycling processes; (2) make deductions from data to describe how physical properties of matter enable various separation techniques to be used, and (3) generally improve their problem-solving ability through practical experience.

**METHOD:** Students will describe physical properties of ten waste items on a data sheet based on their experience with several mechanisms that can be used to separate these waste items. They will be directed to make deductions from the information sheet and asked to design a separation process in stages, using mechanisms introduced previously. Students can work individually, in pairs, or in small groups to compete for the most efficient design. The judgement about which is the "most efficient" should be put to the test by classmates for their observation and measurement.

**BACKGROUND:** Understanding the physical properties of waste materials will help students to appreciate the ease or difficulty with which each is reused, recycled, or disposed. This activity addresses the ways that materials can be handled in order to be separated from each other for recycling or other alternatives.

## MATERIALS:

- Rulers
- Metric scales
- A magnet (preferably a bar magnet attached to a flat piece of wood)

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- A small fan with two speeds or a hair dryer with two speeds
- An aquarium tank or other large vessel for water
- A size sorter (e.g., a cardboard box at least 1' by 1' with 2" square holes cut in the bottom and another cardboard box with flaps taken away but no holes in it)
- For each pair of students or small group, have the following items: aluminum can, tin can, several used or unused staples, pieces of paper or pieces of cardboard, piece of wood, styrofoam container, plastic two-liter bottle and the cup part from the bottle, an orange peel, some steel bottle caps. Have extra pieces of paper or cardboard on hand.

## PROCEDURES:

A. Discuss the concept of properties of matter, i.e., size, shape, weight, magnetism. Discuss the importance of sorting materials according to type before they can be recycled. Show students the pieces of paper and staples. Explain how these often end up together at paper recycling plants and can be separated based on the physical property of magnetism in staples.

B. Explain how all of the items in this activity often end up at refuse facilities such as landfills and incinerators. Sometimes materials which are combustible and organic are separated from those which can be recycled or cannot burn.

C. Divide the class into pairs or small groups. Give each pair or group a set of items mentioned in the Materials section. Discuss some physical properties of the items.

D. Pass out a copy of the handout, Properties of Waste Objects, to each pair or group of students and have them complete it. To do so, they will need to test the items in various ways in order to make choices on the handout. For this, provide rulers, a tank of water, a magnet, a box with holes, and scissors throughout the room.

E. After the charts have been completed, discuss the answers.

F. Display on a large table space the magnet, the small fan or hair dryer, the vessel of water, the size sorting device (box with holes), scissors and cardboard box.

G. Based on information completed on the handout, assign the following task to each pair or group of students.

1. Use the equipment to construct a process for separating all ten items individually. Do this by designing separation techniques in a series of stages. You must begin with all ten items in one pile bunched up close together on the table. You can pick up items to place them where you want them to go each time you make a separation, but you cannot separate them with your hands while using a separation technique. The group that separates the items most efficiently, i.e., in the fewest stages or with the most success, wins.

2. Example: You could demonstrate the following for students to give them ideas. Ask students, based on their information sheet, which items should float and which will not. Put all ten items, as your first stage in the process, in the water.

   Put those that floated on the table in a separate bunch from those which did not float. This represents the first stage or step to be counted in the process.

3. The next step(s) must involve sorting items from each of the two piles. Eventually you want to separate each item individually. The individual separation of one item from the rest could happen in a first step depending on design.

4. Do another demonstration. Use scissors to make a pile of shredded plastic (from the bottle) and of shredded paper. The shredding process represents only one stage although two types of materials have been shredded. Set the fan on the table in front of the pieces of paper and plastic. Put the cardboard box at end of the table. Turn the fan on at a distance from the pieces and at a speed which will blow only paper into the box (or perhaps only the plastic if the paper is wet from having been in the water). Now you have separated these two items in two steps including the shredding process. You have eight more items to separate.

5. Explain that you have deduced this step based on information about the weight of the materials listed on the handout. One important technique would be one that separates the items into three instead of two piles. You may also want to judge designs based on energy efficiency by creating a scale of energy required to use the various pieces of equipment. The team using the least energy could be given a prize.

H. Now direct pairs or groups of students to look carefully at their information sheets, and design stages in a process to separate all of the materials.

I. Each pair or group of students presents their process to the class and to measure which is the most efficient and/or energy saving.

**DISCUSSION/QUESTIONS:** Have students explain what the following terms mean and why they are important for recycling processes.

A. Air Classification System

B. Magnetic Separation Device

C. Water Separation System

D. Size Sorting Device

## ACKNOWLEDGEMENTS:

Our thanks to the Ohio Department of Natural Resources for giving us permission to use this activity from their publication *Super Saver Investigators*.

# PROPERTIES OF WASTE OBJECTS

| Question<br>Name: | Name of Object | Name of Object | Name of Object | Name of Object | Name of Object |
|---|---|---|---|---|---|
| Size (l x w)? | | | | | |
| Weight (oz.)? | | | | | |
| Magnetic? | | | | | |
| Nonmagnetic? | | | | | |
| Floats? | | | | | |
| Sinks? | | | | | |
| Shreds? | | | | | |
| Does not shred easily? | | | | | |
| Other? | | | | | |

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# PART I

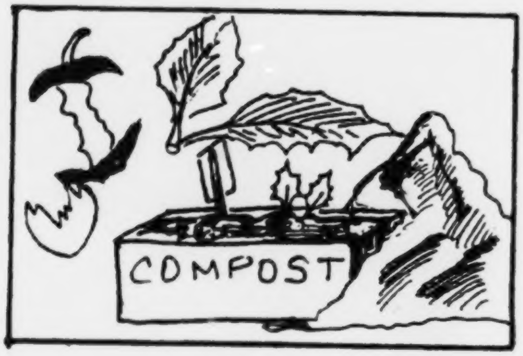
## EVERYTHING ENDS UP SOMEWHERE

- *Developing a School Reduction, Reuse, and Recycling Program*

# STRIKING IT RICH WITH CLASSROOM COMPOSTING

**Subjects:** Biology, environmental science, ecology, science

**Format:** Individual student, student teams; daily checking & record-keeping required for 3 weeks



**OBJECTIVE:** Students will: (1) identify the nine components necessary for making an active compost pile, (2) explain the composting process, (3) identify current and potential markets and uses for finished compost products, (4) describe the benefits of composting as a waste management technique.

**METHOD:** Students construct and monitor a classroom compost pile and discuss the benefits and uses of compost.

**BACKGROUND:** Composting of organic materials is the oldest form of recycling. When dead leaves fall to the ground in wooded areas, they are broken down and decomposed over time by a combination of physical (nonliving) and biological (living) factors. Eventually, the elements and compounds which were once part of the living leaves are released into the air and soil where they can be used to form new plants or other organisms in the endless cycle of life. Given proper conditions, many organic wastes can be decomposed and contribute to the natural recycling process.

Organic materials are carbon-based substances that are or were parts of living organisms. Composting is a process whereby organic material is broken down and decomposed by microscopic bacteria, fungi, and other decomposers, such as earthworms. When organic wastes, such as grass clippings, leaves, sewage sludge, and food waste, are combined with decomposers (bacteria that break down organic materials to smaller chemical units that other organisms can use) and receive sufficient air and water, the decomposing organisms, especially bacteria, proliferate. The bacteria generate a temperature of up to 150 degrees Fahrenheit and literally cook the waste. The finished product, called compost, is an important source of nutrients (such as carbon and nitrogen) for plants.

The large-scale use of composting as a waste management tool could significantly reduce the volume of solid waste which communities send to landfills. At present, few communities include large-scale composting in their waste management programs. A major deterrent to large-scale composting is the lack of demand for the finished composted product. Currently, composted yard waste and sewage sludge are used for soil enhancement and landfill cover and as a top dressing for grassy areas, vegetable gardens, and flower beds. Major purchasers of compost are road and park departments, landscapers, golf courses, campgrounds, airports, and hay and corn farmers. Other potential purchasers include homeowners; managers of cemeteries, forests, and horse farms; topsoil and bark companies; retail farm and garden suppliers; phosphate miners; building contractors; and the fertilizer industry.

In addition to encouraging the development of large-scale composting facilities, states plan to encourage homeowners to use yard and food waste to make their own compost for use as fertilizer and/or mulch. In addition, under new regulations many citizens will no longer be permitted to landfill yardwastes.

**MATERIALS:** The activity requires the following:

- "Striking It Rich With Compost" information sheet -- one per student (see end of activity)
- "Classroom Compost" data sheet -- one per class (see end of activity)
- Wire or screen compost container for outside compost or large glass container for indoor compost
- Organic yard and food waste (leaves, grass clippings, wood ash, sawdust, eggshells, fruit and vegetable food waste)
- Lawn fertilizer
- Dirt or non-sterile potting soil

- 1-2 dozen earthworms
- Thermometer
- Trowel or large kitchen spoon

# PROCEDURE:

A. A few days before the compost pile construction activity is scheduled, ask students to bring in samples of yard and food waste from home. Instruct students not to bring in meat scraps, fats, or oils. Food waste could also be obtained from student lunches.

B. Day 1:

Introduce and define the term compost. Ask students to identify the ingredients they think are essential to a good compost pile and ask students to explain why these ingredients are necessary.

C. Distribute the "Striking It Rich With Compost" information sheet and review the nine components of an active compost pile. Next, explain the composting process and ask students what they think finished compost looks like.

D. As a class, design and build a mini-compost pile in the classroom or outside in the schoolyard. A suggested procedure includes the following steps for composting in a large glass indoor container or wire/screen indoor/outdoor container:

1. Chop the food and yard waste into small pieces;
2. Alternate layers of soil (one inch), organic waste (two inches), a sprinkle of fertilizer, and a sprinkle of water;
3. Place a top layer of one inch of soil on the completed pile;
4. Add additional water as needed to make the pile moist but not soggy (it should feel like a damp sponge);
5. Add earthworms to the top layer of soil;
6. Place a thermometer into the middle of the pile;

E. Place the completed compost pile in an easily accessible area in the classroom (on a plastic sheet if keeping the wire/screen container indoors) or schoolyard and post the Classroom Compost data sheet nearby. Ask students to record the initial temperature, odor, and texture of the compost and list the organic waste materials added to the compost pile in the appropriate boxes next to "Start" on the data sheet.

F. Days 2-20:

Turn the management of the compost pile over to the students. Practices, activities, and timetables should include:

1. Keeping the compost pile away from extreme temperatures and direct sunlight at all times.

2. Examination of the compost pile and recording of observations on the data sheet, noting temperature, odor, texture, and changes observed in the compost pile each day.

   Once each week use a trowel or large kitchen spoon to turn and aerate the compost. On these days, have students make and record their observations before the compost is turned and aerated. Remind students to record the temperature of the compost pile from the same location and depth and at the same time each day.

3. Check the moisture level of the compost pile every few days and add water as needed.

G. Day 21:

Students record the final temperature, odor, and texture of the finished compost product. Ask each student to feel, smell, and look at a sample of the finished compost. Assign the students to construct a graph of the temperature of the compost pile over time and reproduce the completed "Classroom Compost" data sheet on the chalkboard or overhead.

Conduct a whole class discussion addressing the following questions:

1. Why was it important to record the temperature of the compost pile from the same location and depth and at the same time each day?

2. How did the temperature of the compost pile change over time?

3. Why did the temperature of the compost pile change?

4. What odors did you detect during the composting process? Why does compost have an odor?

5. How did the texture of the compost change?

6. What happened to the original organic wastes added to the compost pile?

7. Which materials were broken down and decomposed fastest? Slowest? Why?

H. Ask students what they could do with the finished compost product. Explain that finished compost is a natural fertilizer and tell students that in natural settings, especially wooded areas, dead leaves, branches, and other organisms are naturally composted to produce humus, a nutrient-rich soil.

## DISCUSSION/QUESTIONS:

A. Ask students to list the components necessary for an active compost pile.

B. Ask students to write a paragraph explaining the composting process.

C. Ask students to discuss current and potential markets/uses for finished compost products.

D. Ask students to explain the benefits of large-scale and home composting.

## FURTHER STUDY:

A. Ask small groups of students to design and monitor different kinds of compost piles (one low in nitrogen, one without moisture, one without aerating, one with sterile potting soil, one with a single organic waste ingredient such as banana peels, one without earthworms, etc.). Compare the rates and effectiveness of decomposition between piles.

B. Prepare one compost pile containing large pieces of organic waste and another containing small pieces of the same types of organic waste. Have students investigate how material size affects the rate and effectiveness of decomposition.

C. Collect samples of natural humus from a wooded area. Ask students to observe and compare the texture, odor, and color of natural humus and prepared compost and examine the humus for evidence of decomposers (fungi, earthworms, insects, etc.).

D. If your community has a municipal composting center, take a field trip to observe its operation.

E. Give a student or student team the "Vermicomposting" student activity materials to develop a long-term study of vermicomposting, including conducting food audits, doing school- and home-based composting, using food and/or yard waste, and related activities.

F. As a result of the in-depth study, have students prepare a Composting Fact Sheet and distribute it to classmates and family members.

G. Invite a local landfill operator to take students on a landfill walk to see what becomes of landfilled food and yard waste. Preliminary to the trip, ask students what they think happens to such waste when it is buried in landfills.

If not covered by the waste management representative during the landfill walk, explain to students during or after the walk that most landfills are not exposed to air, a critical component of the natural composting process. Without adequate aeration, most decomposing organisms cannot function properly. As a result, organic wastes buried in landfills can take decades to decompose. In addition, without ventilation, methane gas, a natural product of the decomposition process is trapped in landfills. As methane gas builds up in landfills, it expands and has been known to "float" or lift entire landfill cells. It also can cause explosions.

Now, most new landfills constructed in the USA must include systems for collection and release of methane gas. Explain the benefits of composting as a strategy for reducing the volume of waste sent to landfills and recycling the elements and components necessary to sustain life. Tell students that currently, *by weight, 9% of the solid waste generated nationally* is food waste and 20% is yard waste. *By volume*, 3.3% of solid waste is food waste and 10.3% is yard waste.

## ACKNOWLEDGEMENTS:

Our thanks to the Florida Department of Education for its permission to use and adapt this activity from its *4 Rs Project*.

# STRIKING IT RICH WITH COMPOST

Information Sheet

| Key Component | Function |
|---|---|
| 1. Soil | Contains organisms (bacteria) that help decompose organic materials. |
| 2. Organic wastes – e.g.,leaves, fruit, vegetable scraps, egg shells, and grass clippings--which contain carbon & nitrogen<br>Meat scraps, fats, & oils inhibit decomposition & their strong odors can attract dogs, rats, raccoons,& other animals. They shouldn't be composted. | Alternating layers of high carbon and high nitrogen wastes creates good environmental conditions for decomposition to occur. |
| 3. Fertilizer containing nitrogen or manure or green grass clippings | Many of the organisms responsible for decomposition need extra nitrogen for rapid and thorough decomposition. |
| 4. Earthworms | Eat the waste and help break it down; make droppings which enrich the soil; tunnel through and aerate the waste thus aiding decomposition; eventually die and become part of the compost. |
| 5. Water | Essential component of the decomposition process; too much water can make the compost pile soggy and slow decomposition by reducing need oxygen. |
| 6. Air | Fungi, bacteria, small insects, and other decomposing organisms require adequate amounts of oxygen to survive and function. |
| 7. Time | Decomposition takes time; aerating the compost pile every few days can speed up decomposition. |
| 8. Heat | Heat is a by-product of the chemical reactions occurring during decomposition; a properly functioning compost pile can reach a temperature of 150° Fahrenheit; these high temperatures help sanitize compost by killing weed seeds, pathogens and harmful insect larvae. |
| 9. Mass | In order to generate enough heat for optimal decomposition, a compost pile should contain at least one cubic meter of organic material. |

# CLASSROOM COMPOST

| Age of Pile | Temp °F | Odor of Compost | Texture | Changes in material (size, color) |
|---|---|---|---|---|
| Start (Day 1) | | | | |
| Day 2 | | | | |
| Day 3 | | | | |
| Day 4 | | | | |
| Day 5 | | | | |
| Day 6-aerate | | | | |
| Day 7 | | | | |
| Day 8 | | | | |
| Day 9 | | | | |
| Day 10 | | | | |
| Day 11-aerate | | | | |
| Day 12 | | | | |
| Day 13 | | | | |
| Day 14 | | | | |
| Day 15 | | | | |
| Day 16-aerate | | | | |
| Day 17 | | | | |
| Day 18 | | | | |
| Day 19 | | | | |
| Day 20 | | | | |
| Day 21-FINISH | | | | |

# SCHOOL WASTE EXCHANGE

**Subjects:** Science, social studies, economics, home economics, business education

**Format:** Individual or teams of students over a selected number of class periods

**OBJECTIVE:** To introduce students to the concept of reusing materials.

**METHOD:** Students bring in durable goods (books, toys, pieces of clothing) from home that they or their family members no longer want and exchange them for other items that they **do** want.

**BACKGROUND:** When it comes to responsible waste management, recycling has gotten all the press. Yet, in professional circles, recycling ranks third on the list of environmentally friendly options. What methods top the charts? The time-honored but recently neglected practices of **source reduction** and **re-use** hold first and second place, respectively.

In its report entitled *The Solid Waste Dilemma: An Agenda for Action* (1989), U.S. EPA listed both source reduction and re-use ahead of recycling in its hierarchy of waste management techniques. The rationale for such a prioritization is simple. Garbage that never gets produced will never have to be disposed of. Source reduction also eliminates the need for handling and transporting materials, making it cheaper than other alternatives. In addition, neither source reduction nor re-use necessitates the energy-intensive re-manufacturing step which is required in recycling.

If source reduction is the preferred technique, then re-use is a close second. Practiced for years by the local milkman, re-use went out of style in the years following the Second World War. However, the idea has by no means disappeared. Every time we go to the grocery store, we re-use a shopping cart to gather our selections. Every time we purchase a refillable bottle, we participate in a well-organized system of re-use. There are dozens of other ways that we can give common discards a second life. All that's required is an awareness of the possibilities, a gradual rejection of the "disposable" ethic and persuasion of manufacturers to make fewer disposable and more reusable products.

**MATERIALS:** The exact materials required depend on the approach selected for this activity. In all cases, you will need a place in which to conduct the exchange. In addition, you will need materials to publicize the event.

## PRE-ACTIVITY QUESTIONS:

A. Name some everyday events (garage sales, flea markets) and organizations (Goodwill, Purple Heart, second-hand stores) that facilitate the re-use of old items.

B. List ways in which people are already finding new uses for old materials (e.g., making patchwork quilts out of scrap clothing).

C. Introduce students to the concept of **barter**. What is it? How does it work?

**PROCEDURE:** This can be an extremely useful and educational activity. Any teacher or school administration undertaking it will have to answer a number of key questions about how it will work. Certainly the students themselves should be asked about how to select and to manage the many possible parts. Preliminary to implementation for a one-day (one-time) or a longer-term "pilot" basis, the following issues should be explored:

- Will the exchange be a single event? A program lasting a few weeks or months?
- What will be the parameters of exchange, i.e., what's acceptable to bring in?
- What will be the "rate of exchange?"
- If it's to be one-time event, then students could bring one item for one exchange, the assumption being that unselected items would be taken back by children bringing them or, where appropriate, taken to a Goodwill or other second-hand store.
- Can students donate items without taking something?
- How can you ensure that the event or project won't just be a "dumping ground"?

- How could a classroom or building start with small, specified items (clothes, toys, etc.) and proceed experimentally?
- Could the project be run like a school store, managed by students but with the MAJOR exception that absolutely no money changes hands for the items?
- How could parental permission for exchange items be managed? (Students could draft an official waste exchange form with a sign-off blank for parents.)
- Is it appropriate to have an appraisal, i.e., a valuation of each item? Or should the exchange rate be one item for one item?
- Should there be a "quality control" position, a student who decides whether an item is exchangeable or not?
- If the program is continued, should it have regular hours on specified dates?
- What faculty, parents, or custodians will manage it?

Whatever the final program, it is important to establish some basic parameters for what is acceptable at the exchange, as defined by students.

## DISCUSSION/QUESTIONS:

A. Have students consider why re-use might be preferred over recycling as a waste management method.

B. This activity makes a nice lead-in to exploring the history of bartering. How was it used by Native Americans and Euro-Americans in the seventeenth, eighteenth, and nineteenth centuries?

C. Does our present society use barter to a greater or a lesser degree than earlier ones? If so, then why?

D. What function does money play in society? Why might it be preferable to exchanging goods (transportability, storability, redeemability)?

## VARIATIONS:

A. Expand student exchange to include services as well as goods.

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# BEES IN THE POP CANS

**Subjects:** Social studies, math, language arts

**Format:** A whole class activity that can take a half or a whole class period

**OBJECTIVE:** Students will (1) solve a problem that is both mathematical and social, (2) be able to compare the results of competitive versus cooperative behavior, and (3) understand some of the essential principles of "team building," i.e., there has to be something in it for everyone. Communication and group problem-solving are necessary for individuals in a group to achieve the same goals, and that one individual's refusal to cooperate can impair or destroy the effectiveness of others in the group. This is an ideal activity to use in preparation for the cooperation needed for a successful school recycling program.

**METHOD:** This team-building activity uses both a dime auction and an actual recycling problem common to schools, "bees in pop cans," as its vehicles.

**BACKGROUND:** In a society geared around competition, sometimes people forget the importance of teamwork and cooperation in getting a job done. When developing a comprehensive school recycling program, it is essential for people from diverse areas of the school community to work together, communicate with each other, and respect each other's need to be involved actively and successfully.

You can expect that some of the students who are observing, not participating in, the activity may find the proceedings humorous because they recognize the behavior that's required before those who are actually participating recognize it. You can also discuss this phenomenon: how an outside observer can often see the problem before those involved see it, because their non-participation makes them more objective.

**MATERIALS:** Spare change: about $5.00 in pennies, nickels, and dimes.

# PROCEDURE:

**A.** *Dimes*

1. Choose four or five people from the class, ask them to sit centrally in view of the whole class. Give each student 25 cents in change.

2. Explain that you are auctioning off dimes and that the object of the exercise is for each student to make as much money as possible. Then, moving clockwise, ask the first person how much he or she will give you for the dime. Moving clockwise from the first bidder, ask each person to bid once. Return to the first person to make a second and final bid. Tell students that they may pass in bidding, if they wish. Award the dime to the highest bidder.

3. When the first round of bidders is finished, give the dime to the highest bidder, collecting the amount bid. Then go to the second person and have each person bid again for another dime. Then start with another person and have each person bid again. Once each person in the group has had a chance to be the first bidder, send the group out of the room for a few minutes to discuss the activity among themselves.

4. While the group is out of the room, ask the students who have been observing the process what they believe is happening. Remind them of the rule: each student is to make as much money as possible.

5. Call the group of bidders back into the room and repeat the exercise. If the students haven't figured out the procedure, send them out of the room again to discuss it, reminding them that the objective is for each one to make as much money as possible.

6. The ideal solution is for the members to agree to let each person take a turn in bidding the lowest amount possible, $ .01, with all others in the round "passing" as their turn comes up to bid against the person who started the one-cent bid. With each one having a turn the goal is accomplished: every person will have purchased a dime for one cent, making a nine-cent profit. Then have a group discussion.

# DISCUSSION/QUESTIONS:

- Why didn't anyone make any money during the first round?

- What happened after the group of bidders came back and tried the exercise a second time? Third time (if necessary)?

- Did the group of bidders figure out a strategy to make more money the second or third time? What was the strategy? Why was it successful (or unsuccessful?)

- Why is it important for people to work as a team when they are trying to get a project done? (Ask students for examples from their past where a similar level of cooperation was required.)

- What would happen if members of a school tried to implement a recycling program and each person acted in competition with each other rather than cooperating? Or only participated occasionally? How far would the program get?

### B. *Bees in Pop Cans*

1. **The problem**: there are bees in the pop cans that are being collected for recycling. Perhaps the cans are not being rinsed well enough, so the sweet pop still in them is attracting bees. But the bees are a problem - they are a health hazard, both to those who actually deal with the cans and to the school community in general, particularly those students with severe allergies to bees.

2. Have the students divide into several representative school groups, including students, maintenance workers, and administrators.

3. **The scenario**: the administrators of the school are opposed to continuing recycling at all, at least of cans -- they are concerned about liability issues with the worker's union and with the parents of the students with bee allergies.

4. The maintenance workers are mixed -- some are very enthusiastic about recycling, and others don't really care if the program continues or not -- they just don't want to get stung by the bees. The students want the program to continue, and at least some of them are willing to do a little more work in order to solve this problem, but some students refuse to handle the bags because they fear bee stings, whether allergic to them or not.

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5. Have students brainstorm within their groups about what each group might suggest as a solution to the bee problem. Then have them get together and present their solutions to the other groups, and try to come to a consensus on the best possible solution.

6. Tell students that their solutions should be as environmentally friendly as possible, i.e., it is unacceptable to use commercial chemical products to drive away the bees or to kill them. (However, don't discourage creative thinking: e.g., perhaps students would like to experiment with "natural" solutions -- someone might suggest sprinkling pepper around the rim of collection bins, for example, as an experiment in discouraging bees.)

## DISCUSSION/QUESTIONS:

- How long did it take to come to a consensus?
- What were some of the blocks to consensus?
- Can this process work if each group takes a position and refuses to compromise?
- What ideas did the students generate? (It is acceptable for them to agree to try several solutions on a test basis and then select the most effective, for example. The important element is that the students arrive at this agreement among themselves.)
- Have students discuss the types of attitudes that make cooperation possible/impossible.

**FURTHER STUDY:** This is also a good adaptation for lower elementary grades if teachers don't wish to do the bidding/bee activities.

A. Do an exercise to show the importance of communicating the same message to everyone involved in a project. For example, if a school were to implement a recycling program, it would be important to establish a slogan or message which would be used in conjunction with the program and would be the same for all people involved.

Come up with a sentence, such as "The school that works together will recycle the most and help the environment the most." Line up the students around the room in a single row. Whisper the sentence to the first student, and have her whisper it to the next in line, and so on. The last student to receive the message should say out loud what he heard.

B. Discuss the way that information can become garbled if it is just passed from person to person rather than being given to everyone from a central source.

Ask students to suggest what might happen if directions for how to recycle were given this way. What might result?

## SOURCES:

The Institute's consultant on team building, Dr. Harry Bury, Department of Business Administration, Baldwin-Wallace College, Berea, Ohio, used the dime auction activity in trainer-of-trainer workshops in the fall of 1991 to illustrate the need for cooperative "win-win" solutions.

The "bee in the pop can" problem is one that several schools have reported that prevented an aluminum can collection. We thought it fitting to include it as a hands-on problem solving focus topic for students to address.

## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for writing this activity.

# PLANNING YOUR RECYCLING PROGRAM: A LOOK AT THE DEMOCRATIC PROCESS

**Subject:** Social studies, language arts

**Format:** One class period

VOTE TODAY
FOR RECYCLING
COORDINATOR!

**OBJECTIVE:** To teach students about the democratic process, while at the same time involving them in the planning of the school recycling program.

**METHOD:** Students elect one of their peers to assist faculty and administrators in planning and implementing the school recycling program.

**BACKGROUND:** For years, planning committees have been used by government and private industry to develop and implement important projects. Such committees are often composed of representatives from the various parties affected by the program. Together, these representatives set goals for the project, develop a plan for implementation, assign specific tasks, keep the project on schedule, keep costs down, and work to resolve any problems that arise.

A planning committee organized along this general model is critical to developing a successful recycling program in schools. In order to be effective, such a committee must include teachers, administrators, parents, maintenance staff, food service personnel, grounds workers, and students. The task of this group is to guide the recycling program through its various stages of development. (See the end of this activity for eight recommended steps and their description.) Teachers should contact the school recycling coordinator in order to find out the exact composition and duties of the planning committee.

The strength of such organizations comes from their diversity. Representatives from each of the various departments in the school will bring different concerns and different areas of expertise. In addition to their individual talents, these representatives will also have a whole constituency on which to draw for ideas and know-how.

Each committee member is responsible for reporting back to his or her peers and providing them with an opportunity to voice their ideas and concerns. Thus, in many ways, such planning organizations function as microcosms of representative government. As a result, the formation of such a recycling planning committee can be used to teach students first-hand about the American system of government.

Victorious in the War for Independence from Britain but hobbled by economic impotency, the fledgling United States of America began the task of constructing a democratic system of government. The year was 1785. A decade earlier, the policies of a distant and uncompromising English monarchy had led to war. Now, American leaders were determined to create a government that responded to the will of the American people.

The brand of democracy chosen by America's "Founding Fathers" divided the governing power among three branches: the executive, the legislative, and the judicial. Each branch was set in opposition to the others, exerting some kind of control that the others did not possess. In so doing, our nation's early leaders hoped to establish a system in which each branch would serve as a check on the power of the others, thereby preventing any one branch from exerting too much influence.

At the heart of this system of government lies the concept of representation. Citizens of the country have a say in their own governance through representatives that they elect. If the people are dissatisfied with the performance of any of their representatives, they can vote them out of office at the next election.

Today, more people have the right to vote in the United States than ever before. Even so, many Americans feel increasingly distanced from the democratic process. Instead of exercising the influence available to them, large numbers of citizens are voluntarily opting out of the democratic system. The trend has resulted in national elections in which less than half of the eligible population has voted.

By showing students how the American democratic process works, how they can participate, and the importance of their participation, teachers can have an influential role in reversing this feeling of disempowerment in our country.

**MATERIALS:** The only materials needed for this activity are paper, pencil, and any informational hand-outs on different forms of government that teachers would like to provide to their students.

## PRE-ACTIVITY QUESTIONS:

A. Ask students what the word "democracy" means. Encourage examples.

B. Have students name their U. S. representatives and their two U. S. senators, their state representatives and senators.

**PROCEDURE:** Begin by discussing different forms of government with students. Work with them to define the following terms: **monarchy, constitutional monarchy, oligarchy, theocracy, communism, socialism, dictatorship, democracy, totalitarian, fascist,** and **parliamentary** systems of government. (See end of activity for definitions.) Compare the system of government in the United States with one of the old communist regimes in the Soviet Union or Eastern Europe. Then discuss the concept of representation. Ask students why people around the globe are willing to die in order to win this right. Conclude by having the class list some personal characteristics that would be desirable in a good representative.

Now mention that the school is putting together a planning committee to set up a school recycling program. Students have been given a chance to be represented on this committee. Other members of the committee will include school administrators, teachers, maintenance staff, and kitchen staff (teachers should contact their school recycling coordinator in order to find out the exact composition and duties of the planning group). Next go over what is expected of the student who gets elected and reiterate the important qualities of a representative. Define the terms of office. Ask students to nominate candidates.

In order to be considered a full-fledged candidate, each nominee must write a campaign statement on what the important issues facing the planning agency will be and how his or her qualifications make the candidate well-suited to the job. Older students can put on a mini-debate and hold a question and answer session as well. Once all the campaign statements have been distributed to the class and read by the students, hold an election. Make sure to emphasize the democratic principle of "one person, one vote." Teachers who want to add an element of realism to the election process can set up a mini voting booth similar to the ones used in local and national elections. Once all students have voted, count the votes and determine the winner. Make sure to thank the other candidates for participating. Their involvement is critical to the democratic process. Without them, students would not have had a choice of candidates, and thus, would have lost a critical element of elections in a democracy: the right to choose.

The student who wins the election will then be responsible for attending the planning committee meetings, representing the views of his or her classmates at these meetings, and reporting back to the class. Teachers should set aside some time for these reports and for brief question and answer sessions between the representative and his or her constituency. Teachers should conclude the whole exercise by saying that democracy brings with it both privileges and responsibilities. This is true both for the representatives and the voters.

The "results" of this activity are immediate but also ongoing, as the students' views are represented by their elected official.

A. Is the class happy with the way the election has turned out? What would they do next time to improve the election procedure?

B. After their representative has begun to perform his or her duties, ask the students if there are ways to improve how they have been or are being represented. What are their suggestions?

C. What can they do in real life if they are not happy with their representative? Ask students to think of examples from actual political life (recalls, impeachment, letter-writing campaigns, etc.).

D. Ask students if they learned anything about the democratic process that they didn't know, understand, or appreciate before. If so, what?

## DISCUSSION/QUESTIONS:

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D. Did they learn anything about the democratic process that they didn't know, understand, or appreciate before? If so, what?

More broadly based discussion about government and representation is relevant to explore as well:

E. Why do so few people vote in national elections in the U. S. when people in other countries are willing to die for the right to vote?

F. Why do many Americans feel estranged from the democratic process?

G. What does it take to re-empower people?

H. Do we have a duty to participate in the democratic process?

I. What does it take to be a responsible citizen in a democracy?

**VARIATIONS:** This activity can be as simple or complex as the teacher wants. Instead of electing a permanent representative who plays an on-going role in the planning process, younger classes could elect a student to sit in on one meeting and then report back to the class.

Older students could compare and contrast their recycling committee representative system with the American system as it now stands. How accurate an approximation is it? How can it be improved?

**FURTHER STUDY:** Ask students to research an environmental issue that is being debated in Congress and then write a letter to representatives and senators. Some useful tips on writing effective letters include the following:

A. Keep the letter short and to the point. Try not to exceed one page at most;

B. Address the letter to the representative or senators in your district or state (For mailing information, call the **White House at (202) 456-1414**, the **U.S. House of Representatives at (202) 225-3121**, and the **U.S. Senate at (202) 224-3121**); and

C. Be sure to mention the bill in question, include a statement that clearly indicates whether you are for or against it, and give reasons supporting this opinion. (If you do not know the bill number of a particular piece of legislation, you can find it by writing to: **The U.S. Government Printing Office, 941 North Capitol Street, Washington, D.C. 20401** or by calling **(202) 783-3238**).

## ACKNOWLEDGEMENTS:

Our thanks to Ben Hitchings for writing this activity.

# DEFINITIONS OF TYPES OF GOVERNING SYSTEMS:

(Definitions paraphrased from Webster's *New World Dictionary*)

**COMMUNISM:** A system of government marked by a one-party political structure, central control of the economy, and an emphasis on the requirements of the state rather than on individual liberties

**CONSTITUTIONAL MONARCHY:** Rule by a monarch in which the monarch's power is limited by a constitution that bestows certain rights on some or all of the residents of the country

**DEMOCRACY:** Rule by the people through elected representatives

**DICTATORSHIP:** Rule by an individual with absolute power whose pronouncements on various topics are considered to be final

**FASCISM:** Rule by a rigid one-party dictatorship that includes elements of nationalism, racism, and militarism

**MONARCHY:** Rule by one person, or monarch, in which there is no limitation on the monarch's power

**OLIGARCHY:** Rule by a few persons

**PARLIAMENTARY SYSTEM:** Rule by a parliament composed of several different parties and headed by a prime minister chosen from the majority party

**SOCIALISM:** A system of government in which ownership of the means of production and distribution of goods and services lies in the hands of the community as a whole, with each member sharing the work and the products.

**THEOCRACY:** Rule by religious leaders who claim to receive their authority from a divine being

**TOTALITARIANISM:** Rule by one party or group that forcibly suppresses all others

# A SCHOOL-BASED WASTE MINIMIZATION AND EDUCATION PROGRAM

## THE 8-STEP PROCESS & THEIR CHALLENGES

**STEP 1:** **FORMING THE PLANNING COMMITTEE**

What are the criteria for the Planning Committee membership? (Whether you represent a single school building, or your entire district, name candidates for as many of the criteria as you list.)

**STEP 2:** **ANNOUNCING THE PROGRAM INHOUSE**

To ensure all-school participation, how will you carry out this step and, later, Step 6? Step 2 takes place a matter of days after this Introductory Training Workshop. Step 6 will be several weeks afterward, immediately before you wish to begin full program operations.

**STEP 3:** **GATHERING INFORMATION**

**INTEGRATING WITH THE COMMUNITY PROGRAM**

**LEARNING ABOUT LOCAL MARKETS FOR RECYCLABLES**

How will you gather information about the school's waste generation quantities, types, and sources? How can they be integrated with the community recycling practices? What markets are available for your recyclables?

**STEP 4:** **DESIGNING THE PROGRAM PLAN**

**SECURING PROGRAM COMMITMENT**

What factors will you need to consider before recommending a waste minimization and education program?

**STEP 5:** **PREPARING TO PURCHASE EQUIPMENT, SUPPLIES, AND MATERIALS**

You will need to calculate and project the real costs of implementation. These will be compared to savings, or earnings, from your program. What estimate do you think would represent fairly the real costs of the program?

**STEP 6:** **INVOLVING, TRAINING, AND IMPLEMENTING**

Your program has been approved, endorsed, and you have acquired all of the supplies and materials you need to proceed. How will you kickoff the campaign to help ensure full participation?

**STEP 7:** **PURCHASING RECYCLED/RECYCLABLE MATERIALS,**

**REDUCING AND REUSING WASTES AT SCHOOL**

To "close the loop," your school needs to buy products which are made of recyclable materials. This will encourage the companies which supply those products to purchase more and more recycled materials, perhaps from your own school. How would you answer this challenge?

**STEP 8:** **EVALUATING & REPORTING**

How will you judge the effectiveness of your program? What records need to be established and then maintained for this purpose? Who will do that?

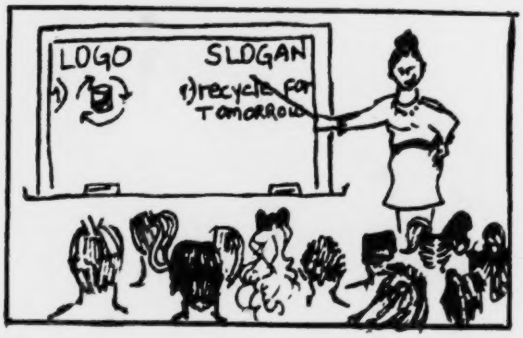
**GOAL:** **BEING A MODEL PROGRAM**

What, in your opinion, would constitute a "model program"?

# PROGRAM PROMO? TRY A LOGO/SLOGAN CONTEST

**Subjects:** Art, journalism, language arts

**Format:** Assignment can be started in class and continued as a home assignment or on-going classroom project



**OBJECTIVE:** Students will (1) learn to generate a high-quality, effective logo and slogan to be used with the school recycling program, (2) learn about basic communication and advertising techniques, and they will (3) generate enthusiasm for school recycling.

**METHOD:** Students learn basic principles about the way that logos and slogans influence how we think about the products and companies they represent; then students design, publicize, run, and judge a school-wide contest to choose an effective logo and slogan for the school's recycling program.

**BACKGROUND:** For centuries, people have used posters with pictures and, often, slogans on them in order to advertise products or ideas. The pictures show an ideal of some sort, whether it is of physical beauty, good health, an image of "the good life" and the material goods that go along with it, adventure, or attractiveness to the opposite sex. These ideals, associated with a product or idea, are meant to sway one's feeling about the product or idea so they will buy or accept it.

Slogans (catchy phrases) and logos (simple symbols) are valuable because they promote a program with a simple symbolic representation. They are attractive and grab one's attention. They stimulate instant recall. And they promote personal identification with the program.

Research of recycling programs in various sectors, both municipal and school-based, around the United States has shown that recycling programs with a consistent,

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coherent, recognizable message and associated visual symbol are much more likely to have strong participation than those which do not.

This message can be encapsulated in a combined slogan and logo. When the slogan and logo are used consistently in every aspect of the program, people come to associate the slogan/logo combination with the recycling program. This can be very effective in raising program awareness.

This is a useful activity for students because it teaches them to communicate well both in running the contest and in designing entries.

## MATERIALS:

- Paper and drawing/writing implements.
- Sample Logos at the end of the activity

## PRE-ACTIVITY QUESTIONS:

A. List three well known slogans and three well known logos that advertise certain products, companies, or programs. Why are they memorable? What makes them effective?

B. What does the standard recycling logo with the three arrows represent? What makes it effective? (Some possible answers include the fact that it is standard and is seen everywhere, it is simple, and the three connecting arrows in a triangular arrangement are appropriate -- they represent the endless cycling of materials).

## PROCEDURE:

A. If your school already has a recycling committee, coordinate this assignment with its plans and needs. School administrators should first be informed of the plan to develop a recycling logo/slogan contest and should approve it since it would be a school-wide project. Also, teachers all over the school should be notified, and you should verify that the winning logo/slogan combination will be used as the official representation of the school's recycling program.

B. Study some well-known slogans and logos, including those for existing recycling programs (we have included some from other states at the end of the activity). Discuss how logos and slogans represent the values of the product or organization being promoted. Discuss what values are being promoted by these recycling logo/slogans.

C. Ask students to break into groups. One group will draw up a plan and a timeline for the contest. One group will start making posters to publicize the program. Another will start acting as a contact between the class and the school's recycling committee, to ensure that the winning slogan and logo will actually be used on bumper stickers and other items to represent the program.

D. The first group will submit its plan and timeline within half or a whole class period. Make sure the plan and schedule includes the following:

   1. Delineation of desired values that entries in the logo/slogan contest should attempt to portray;

   2. Deadlines for submissions and a date at which the contest will be judged;

   3. Desired size (i.e., physical dimensions) of the entries and any other specifications, such as black and white format only;

   4. A decision about who will judge the contest -- all or only some of the students from this class -- perhaps designating a group of student judges.

E. The second group will put up posters advertising the contest and write announcements to be read over the P.A. system. If there is adequate lead time, publicize the contest in the school newspaper or other bulletin going to students. Also prepare simple flyers to give out to all students in the school.

F. Make sure that the third group of students is able to guarantee that the winning entry will definitely be used on all posters, bumper stickers, t-shirts, and flyers that relate to the school's recycling program.

G. Hold the contest, judge the entries, etc.

## DISCUSSION/QUESTIONS:

A. How do slogans and logos help to advertize a recycling program?

B. What makes the new logo/slogan for your school recycling program an effective one?

## VARIATIONS:

A. If your school does not yet have a recycling program, have the logo/slogan contest be merely for your class, and save the entries for a future program.

B. Or, have a school-wide logo/slogan contest for some other program that is already in existence.

**FURTHER STUDY:** Students might bring in advertisements from magazines or newspapers. What product or company is being promoted? What is the image or idea used to convince people to buy the product? What audience is being targeted in particular; i.e, young people, women, wealthy people, etc.? What logos or slogans do they use?

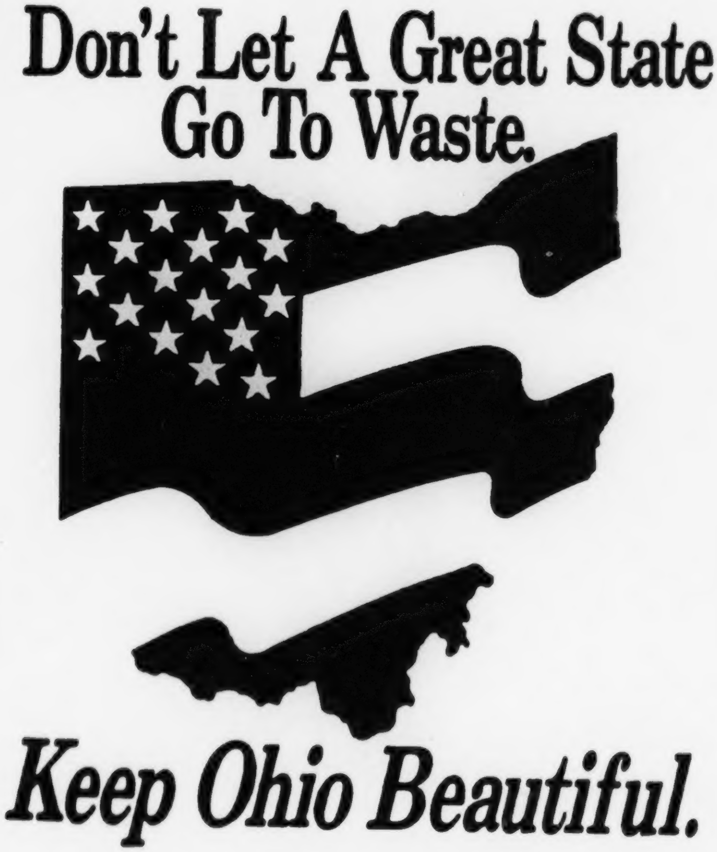
## SOURCES:

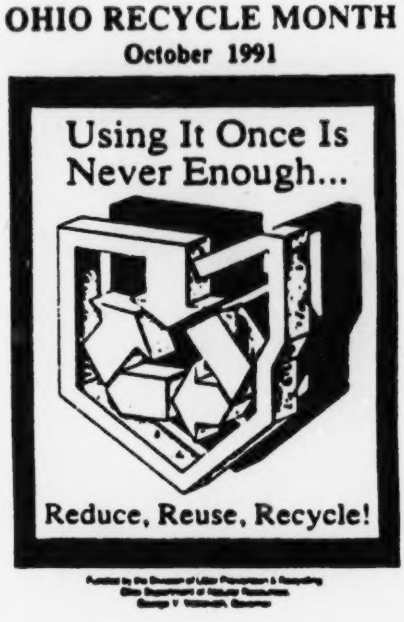
Margolin, Victor, et al. *The Promise and the Product: 200 Years of American Advertising Posters*, New York, NY: McMillan, 1979.

## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology for its permission to use its "Logos and Slogans for Recycling" from its *A-Way with Waste* publication as a basis for this activity.

## SAMPLE LOGOS


Don't Let A Great State
Go To Waste.
Keep Ohio Beautiful.


OHIO RECYCLE MONTH
October 1991
Using It Once Is
Never Enough...
Reduce, Reuse, Recycle!

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WASHINGTON STATE
DEPARTMENT OF ECOLOGY

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CLEAN UP OHIO
LITTERALLY

Virginia Division
of Litter Control

1215 Washington Building
Richmond, Virginia 23219
804-786-8679

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Recycle New Mexico

# WE'RE ALL IN THIS TOGETHER

**Subjects:** Language arts, journalism

**Format:** Several class periods to prepare, one assembly or an hour after school for the actual press conference

## OBJECTIVE:

Students will (1) plan an actual press conference with media to announce their school's recycling program and they will (2) learn about good communication and public speaking.

## METHOD:

After writing and distributing a press release to local media, older students will **assist** younger students in preparing for a press conference. The older students will also interview the younger ones to learn their concerns, interests, and knowledge about environmental issues.

## BACKGROUND:

This is a good opportunity for students to learn to deal with real-world media, since recycling is a hot topic that is receiving a great deal of media coverage.

A press conference is an opportunity for someone involved in an important project to announce it publicly and to answer questions. If you can get members of the media to come to your school to interview students, the publicity for both the school and the recycling program could be a way for the school to interact with the community.

The elements of a press conference include a prepared statement by the holder of the conference to the members of the press. Then the session is open for questions of those conducting it. The reader of the prepared statement should introduce others besides herself/himself who will be available for questions. Titles, responsibilities, etc. should be provided in writing to the press, as well as the name and phone number for a person to be contacted if there are questions afterward.

Be sure to set aside a room where you can hold the conference, and include that information in your invitation to the press.

## MATERIALS:

- Sample press release (see end of activity)
- Videotape and/or transcript of an actual press conference (such as a Presidential press conference)
- Tape recorder
- Writing implements and paper

## PROCEDURE:

A. Make sure you clear the idea of a school-wide press conference with the principal, and set a date to conduct it.

B. Have a discussion in class about what makes an event newsworthy.

C. Have students attend or view a videotape of an actual press conference to give them an idea of what a press conference is like. Then discuss the elements of a press conference.

D. Distribute copies of an official press release and discuss it -- the six main ideas to convey in a press release are **what, where, when, why, who's involved, and how**.

E. Students then can begin writing their own one-page press release announcing their recycling program and the upcoming press conference.

F. Call for the mailing addresses of various media and then send copies of the press release.

G. Then students can begin planning the press conference. They may designate an official student spokesperson (maybe two or three) and plan what items of information those people should primarily try to convey (whatever they feel is notable, unique, and interesting about their recycling program).

H. Other students can contact media a few days after the press release has been mailed to confirm that it was received and to invite a reporter to attend the press conference.

I. One or two students could set up a public address system to ensure effective communications.

J. If external media are unable or unwilling to come, plan to have a group of students play reporters and plan out a long list of questions to ask the student recycling program spokesperson.

K. Hold the press conference. Invite students, teachers, staff, and parents. Record the press conference with a tape recorder, so that students can study it later.

## DISCUSSION/QUESTIONS:

A. What makes certain events newsworthy? What makes your school's recycling program newsworthy?

B. What are the main ideas to express in a press release?

C. What did you think of the official press conference you attended/viewed? What was surprising about it? Did the people being interviewed always answer exactly what was asked, or did they only give out information that made them look good?

D. What did you learn from holding your own press conference?

**VARIATIONS:** Let younger students prepare questions and interview the older students instead of inviting outside members of the press.

**FURTHER STUDY:** Write up the events of the press release from the tape recording and put them in the school's recycling newsletter (see the activity, "Recycling News"). Also, have the older students interview the younger ones about their concerns and interests in recycling and the environment, and write that into an article for the recycling newsletter.

## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for writing this activity.

# SAMPLE PRESS RELEASE

**FOR IMMEDIATE RELEASE**

**TO:** Greater Cleveland Area Print and Broadcast Media and Area Schools

**RE:** Grants Received by the Institute for Environmental Education to Implement Its School-based Waste Minimization and Education Program

**FOR FURTHER INFORMATION CONTACT:**

Joe Chadbourne
Institute for Environmental Education
18554 Haskins Road
Chagrin Falls, Ohio 44023-1823
Tel: 216/543-7303; FAX: 216/543-7160

**DATE:** August 16, 1993

The Institute for Environmental Education today announced the receipt of three foundation grants to help implement Ohio's first School-based Waste Minimization and Education Program. Based on Ohio H. B. 592, which requires a 25% reduction in solid waste to landfills by June 24, 1994, the School-based Waste Minimization and Education program uses schools as community educators about waste reduction and recycling.

The School-based Program teaches students and teachers about waste reduction and recycling through hands-on activities such as building composting bins, measuring school waste, and writing recycling press releases. The Program enables administrators and staff to reduce, reuse, and recycle waste in every school building.

Students then work with their families at home to reduce, reuse, and recycle wastes, and to encourage recycling program start-ups in their parents' workplaces.

--more--

Institute President Joe Chadbourne says the Program's strength is in its ability to reach thousands of Greater Clevelanders inexpensively. "By studying schools as generators and managers of waste, students and adult staff will experience first-hand the need for changes in buying habits and lifestyles."

The Program will eventually include over 150 school buildings in 35 Districts, including the Cleveland Public Schools. In addition, over 120,000 households in the Greater Cleveland area will participate, helping to cut trash hauling fees while educating citizens about resource conservation and environmental principles.

This Program is made possible by three Foundation grants: BP America, $5,000; the Gund Foundation, $21,500; and the Cleveland Foundation, $36,340.

For more information, contact Joe Chadbourne, Institute for Environmental Education, at 216/543-7303.

--30--

# RECYCLING NEWS

**Subject:** Language arts, journalism, art, photography, speech

**Format:** A long-term project appropriate for an entire elementary school; should be coordinated among faculty to assure continuity and representation of all grades

RECYCLING TIMES
TOXIC WASTE SITE DISCOVERED BY LAKE

**OBJECTIVE:** Students will write a recycling newsletter (1) to inform the school community and parents about the school's recycling activities and (2) to teach students about principles of journalism, data management, source verification, and cooperation.

**METHOD:** Students will write and publish a recycling newsletter.

**BACKGROUND:** Effective writing and communication skills are extremely important for people in many careers today. A recycling newsletter is a good way to relate writing to an active program in which students are taking part. Also, a recycling newsletter serves an important function in informing the school and parent community about the progress of the recycling program.

The beauty of a recycling newsletter is that it can involve even the youngest students -- through their artwork or through older students interviewing them about their thoughts on topics such as the recycling program or the environment. Having your words, artwork, or photographs in print can be an exciting event for any student and can hook them on learning the skills that allow them to publish their work: writing, grammar, interviewing skills, artwork, photography, organizing and managing, etc.

For older students, grades 5 on up, the old maxim that "The pen is mightier than the sword" will remind them that the written word is an effective tool for changing opinions and communicating ideas, and that an effective open channel of communication is better than squaring off and fighting to achieve an end.

An effective journalist uses many sources and attempts to distinguish between "fact" and "opinion" -- something that is objectively true, like the fact that steel is magnetic and aluminum is not, versus an opinion like the idea that glass should be the only substance of which beverage containers can be made. A fact is a piece of information that is supported by evidence, whereas an opinion is a belief that may not be supported by evidence.

The three major components of a newspaper are editorials, news stories, and photo/feature stories. The last two are based primarily on facts (ideally), whereas editorials are usually expressions of opinion. Remind students to apply these principals in their newsletter. (When papers go "commercial," of course, another component is the ad.)

## MATERIALS:

- Ideally, at least one word-processing computer and printer; or typewriters; if the hardware is unavailable, elementary kids, especially, can practice their very best printing!
- Scrap paper for drafting stories (this is an excellent opportunity to have students use both sides of the sheet)
- Rulers and tape for laying out the copy on the page
- Camera, film, access to a darkroom or to photo-finishing
- A photocopy machine (or donated photocopying)
- Recycled paper for the finished edition, with a "recycle" logo on it

**PROCEDURE:** The following directions are for older students; elementary teachers can easily adapt them for the lower grades by emphasizing the "news" aspect for readers (parents, community members) and the importance of gathering accurate facts about their program (what is recycled, how many containers there are in the school, how long the program has been running, etc.).

A. Start by distributing to the class samples of the three types of newspaper articles: an editorial, a news story, and a photo/feature story. Discuss the characteristics of each one and stress the difference between fact and opinion.

B. Divide students into groups: one will gather information pertaining to the recycling program, such as the amount recycled (in tons), the cost of the recycling program, and any revenue from the sale of materials. Work closely with this group to ensure that they have accurate information. Another group will actually write articles based on that information.

C. Another group, those with some artistic skills, will draw or photograph various aspects of the program to elaborate on or confirm the text.

D. Another group will procure the paper and supplies for printing. This group will also calculate how many copies of the newsletter are needed for distribution to all members of the school community. They will try to get access to computers and printers, if the class does not already have some -- they could do a survey of parents who have access, talk to school administrators and others about where they might have the text typed and printed.

E. All groups should be alert when talking to students, teachers, staff, and administrators for recycling anecdotes that have occurred since the program began. These anecdotes can be compiled and included as an article or in boxes in the newspaper text.

F. Students will write articles, take photographs, draw pictures, and do basic layout for the newsletter. Sections might include: "How to Recycle," "Program Update," "Astonishing Facts about Recycling," "Recycling in Our City," "What You Can Do at Home and in Your Community." If the class has access to a computer and printer, the newsletter could just be printed out, although artwork or photographs would have to be worked into the text layout. If the computer software has graphic capability, clip art could be substituted.

G. Quality checks -- the process of reviewing, correcting, editing, and otherwise polishing stories -- are one of the most important components in producing a professional job, no matter how humble or sophisticated the format. You should spend some time with students explaining why it is necessary: well written articles are more interesting than rambling ones, and show respect for the reader's time. Good grammar and correct spelling reflect well on the student and the teacher. Teachers should provide examples for the students to evaluate.

Also, teachers should develop a policy about by-lines. They add weight to the individual student's responsibility to do a good job and let everyone know who did it. Any child will be pleased to see his or her name in print. Artwork and photo credits should also be noted.

H. The class will print this newsletter and distribute copies to the school community. Consider having kids hand deliver copies to merchants, city officials, etc. This saves on postage and gives students the opportunity to meet the people who support the schools, and vice versa.

**DISCUSSION/QUESTIONS:** After the stories have gone to press or after the first issue comes out, discuss the following:

A. Ask students what they learned about communicating their ideas. How was this assignment different or similar to a regular school assignment?

B. What are the qualities of an effective news story, editorial, or photo/feature story? Would models be helpful next time? How would you find them?

C. Did the students use several sources to come up with their major stories? Did they encounter statements that were more opinion than fact? Discuss.

D. For students who did interviews, what did they discover about note-taking, recording people's words accurately, etc.? Were they nervous? Discuss.

## FURTHER STUDY:

A. Collect a clip file of newspaper articles on recycling, waste management topics and local waste management issues, litter, the environment. Identify the issues of most interest in your school and community (i.e., is the local downtown area plagued by littering? Are there problems with a nearby landfill -- truck traffic noise, odors, leaks? Are there any breakthroughs in recycling styrofoam? Other less common plastics? Are there any controversial facilities such as incinerators or hazardous waste landfills planned for your area?) Discuss how these issues are portrayed in the articles.

B. Ask students to research whether or not any local papers are printed on recycled paper, and discuss the useful purpose served when they are (i.e., providing a market for all the newspaper recycled).

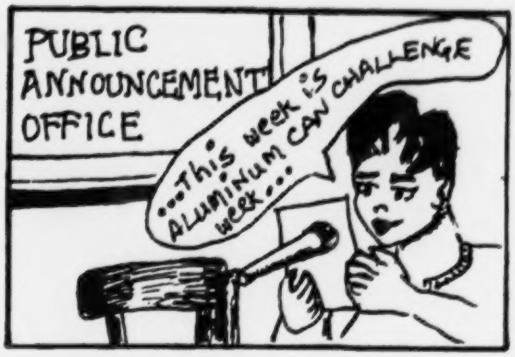
# ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for adapting this activity in part from the Florida Department of Education's *4Rs Project*, and our thanks to the Florida Department of Education for its permission.

# LET'S WRITE IT & TELL IT, SHAPE IT & SHOW IT!

**Subjects:** Language arts, reading, speech, drama, art, social studies, citizenship

**Format:** Series of class periods and/or free-time spread out over the weeks preceding and after the recycling program's start-up in your school


PUBLIC ANNOUNCEMENT OFFICE
...This week is ALUMINUM CAN CHALLENGE week...

**OBJECTIVE:** Students will (1) develop feelings of ownership about the recycling program and understanding of the importance of clear communication by writing and broadcasting public service announcements to students and staff in their buildings and by developing art work and signs that show the steps of recycling and the proper disposal of waste -- both for display in the building; they will also (2) build their ability to work cooperatively in teams; and (3) practice their language, speech, and art skills.

**METHOD:** Students will write announcements for delivery over the public address system, read those announcements themselves, and make signs and artwork that support the recycling programs' goals in the building.

**BACKGROUND:** In order for a recycling and waste reduction program to be successful, students need to understand its goals and why those goals are important to them personally and to others. One of the best ways to accomplish this is to involve students actively in the real work of the program, giving them both the responsibility and power to help realize the plan.

Most students have watched lots of TV and many movies already, and will have some role models for performance already in mind. By focusing this experience on the school's need for announcements, signs, and artwork that tell how the program works and help make students aware of the benefits of recycling, even very young children can be engaged at the very beginning as key resources in helping the program to succeed.

**MATERIALS:** Contact the recycling committee chairperson for a copy of your school's recycling program plan and policy. Both signs and announcements will require these details so that the content that students generate is accurate and supports the priorities of the program. Make copies or a summary available to students: it could be posted on the wall, for example.

A. For signs and artwork in the building

(NOTE: Teachers might want to work together to do this project; e.g., teams of language arts and art teachers, etc.)

1. Posterboard or other paper (construction, plain 8.5 x 11 bond) that can be pinned or taped to the walls or bulletin boards; collages may involve many different paper types as well as fabrics and "found" art materials (labels from cans, lids, drinking straws, styrofoam cups, etc.). Artwork need not be limited to paper or canvas format: students may wish to do sculpture, bas relief, paper mache, etc.

2. Depending on the teacher or student choices, materials may include crayons, paint, brushes, magic markers, pastels, paste, software for computer-generated art and signs, and simple charcoal sketching materials.

3. A copy of your building's policy on posting signs and artwork; special permit to post, if required.

B. For announcements

1. Either a team of students who serve as coaches in rehearsal of their classmates or a tape recorder and blank tape for students to record and playback their announcements at self-rehearsal. If a tape recorder is used, appoint one student to be responsible for it and to instructor others about its proper operation.

2. A clock or watch with a second hand to time announcements.

3. Permission from the principal to have students perform a series of announcements about the program, e.g., over a three-week period, perhaps two a day (morning and before lunch).

# PRE-ACTIVITY QUESTIONS:

A. If students have only 15 - 30 seconds for an announcement, how can they make their messages interesting, understandable, and educational?

B. Are there some very short announcements on TV that students believe are effective? What are they?

C. Why do they think those TV spots work well? Do they rhyme? Do they have music with them? (Ask students to be as specific as possible about what they believe are the right ingredients.)

D. What signs have they seen that are equally effective? Ask for examples. Did they use photographs or drawings? Were there many words or was there just a picture? How did the sign get its message across?

E. What artwork have they seen that has helped to state an idea or create awareness about a problem? Describe the feeling or idea the art work created. (Artwork should include any logo/slogan if the school has already developed one for its recycling program.)

# PROCEDURE:

A. Decide which one of the three activities you are going to do (D, E, & F, below). With older students, teachers may wish to do all three. If so, you may want to divide students into three teams: those who will produce program announcements, signs, and art. You can either rotate all students through the three activities or assign them to one of the three activities.

B. Review the recycling plan goal, what is being recycled, how, etc. Discuss the logo/slogan for the program, if applicable.

C. Settle on ideas for each group. For example, "announcement writers" might be asked to focus on the importance of working as a team. "Sign makers" might focus on the nuts and bolts of "how" to participate, showing in their work what materials are recycled and where. "Artists" might be asked to focus on "awareness" as their goal -- what a litterless environment might look like, what a littered environment looks like.

D. ANNOUNCEMENTS:

1. From the Pre-Activity Questions, remind students what they said works best for a 15 - 30 second message. Repetition? Rhyme? A slogan? The same thing each day? A slight change each time in the same message? Humorous? Enthusiastic?
2. Ask students to work individually or in small groups to write their announcements.
3. Assign students to read messages aloud to fit the assigned time.
4. When a number of messages have been written, ask students to read them out loud to the class for reactions, suggestions, and comments.
5. Students make revisions.
6. Students practice announcements.
7. Students schedule the announcements; assign students to review office procedures reporting times, and other requirements.

E. SIGNS:

1. From the Pre-Activity Questions, remind students about some sample signs they found particularly effective. What were their characteristics? Clarity of message? Pictorials? No words?
2. Have students work on designs for ideas that need signs to describe the plan.
3. Assign students to draft materials and present them to the class.
4. After this review, students finish their work. Several possibilities for them include:
    a. Submitting them to the Recycling Committee members in the building to select one or several for reproduction and use.
    b. Choosing one effective design and then extending that design into other signs for still more recycling instruction and reminder signs.

F. ARTWORK:

1. Using the program plan once again as the guideline for artwork, establish criteria with the students and assign preliminary drawings.

   Arrange safe storage sites for their work.

   Since some students will want to do a major work, while others may wish something on a smaller scale, the artwork option may be an ongoing project for a few weeks. But it would be ideal to have its conclusion be an exhibit in the classroom or in the school halls display cases.

2. Younger students may not be familiar with an extended project, but this might provide an opportunity for them to learn what they can produce over several work periods.

4. When works are finished, arrange a time for students to show their art to the class and comment on how it supports the recycling program.

## DISCUSSION/QUESTIONS:

Regardless of the activity -- announcements, signs, or artwork -- ask the students the following questions:

A. What message did they finally convey through their work?

B. What was the easiest part of their project? The hardest part?

C. What comments did they hear from others, if any, that surprised them?

D. How did they feel about the other students' work? How would they describe it?

E. Do they have evidence that their work has helped the recycling program? If so, what? If not, what could they do next time to improve effectiveness?

F. What did they learn about communications? Discuss.

## ACKNOWLEDGEMENTS:

Our thanks to Mary Chadbourne for writing this activity.

# IMPLEMENTING THE RECYCLING PROGRAM: A LOOK AT THE FACTORY SYSTEM

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**Subjects:** Industrial arts, art, mathematics, language arts, social studies

**Format:** One class period to get activity and assignments underway; independent work in shop and arts classes and/or after school or at home; one class period to follow up on activity results

RECYCLE
ALUMINUM
CANS HERE
PAINT

**OBJECTIVE:** To have students set up the school recycling program, while learning about how a manufacturing company works.

**METHOD:** Students take on the roles of different workers and managers in a factory in order to produce the signs, bins, and other collection equipment needed for the recycling program.

**BACKGROUND:** During the course of a day, the average American generates about 4 pounds of garbage. Nationwide, this so-called "municipal solid waste" totals about 180 million tons. Over the same one-year period, the amount of solid waste generated by industries around the country is almost 50 times that amount. (Source: U. S. EPA).

These figures suggest that in order to work effectively toward a solution to our solid waste problem, we must address not only the waste generated by residential and commercial areas but also the refuse produced by industries. Yet we cannot begin to assist in streamlining our manufacturing processes if we are unfamiliar with the basic manner in which these companies function. Thus, the first step in figuring out how to cut down on industrial waste is to learn how manufacturing facilities operate.

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Just about everything we use, from toasters to shower nozzles, is produced in a factory. Yet many of us have never been inside a factory or are even familiar with how one works. From the purchasing department that prices raw materials to the engineering department that drafts construction plans to the workers on the assembly line that put the pieces together, each group within a factory must work together in order to assemble the product that ends up on the showroom floor.

This activity will introduce students to the factory system, while at the same time it will employ their energies in implementing or up-grading the school recycling program.

**MATERIALS:** The exact materials needed for this activity depend on the layout of the school and the degree to which it has implemented a recycling program. The options listed below illustrate how the program can be used in two different kinds of school situations.

A. Schools that are planning recycling programs can integrate this activity into their implementation plans. Students can contact the school's recycling planning committee in order to discuss the types and quantities of equipment needed for the recycling program and then proceed to manufacture it in their model factory.

B. Schools that already have programs in place can use this activity to upgrade their existing operation. Once again, communication with the recycling committee or the person(s) in charge of the program is essential.

**PROCEDURE:** Ask students to form a company in order to produce equipment for the school's recycling program. Name the firm and determine who is going to perform each of the various tasks within the company. Each student can play several roles, i.e., fill more than one position in the company, since some positions will demand more work than others. (See the description of positions in the paragraph that follows.) The exact work assignments can be drawn from a hat, assigned by the teacher, or selected by students by having them write down their first, second, and third choices and then matching the students with their stated preferences.

Before specific work assignments are determined, the teacher should go over with the students what each position in the company entails. Here is a list of some of the different positions that need to be filled within the company:

A. **Company Executives** are responsible for finding out the equipment needs of the recycling program from the school's planning committee and for making arrangements with the school shop or with community resources such as local trade schools to use saws, hammers, and other production equipment;

B. **Engineers** determine how the company is going to make this equipment and generate design plans (this can also include producing a scale model for other employees to use);

C. **Purchasers** learn where to buy the raw materials and how much they cost;

D. **Line Workers** assemble the various parts into a finished product;

E. **Production Managers** oversee the line workers to make sure that each product matches up with the design plans of the engineers and to make sure that the product is completed on schedule;

F. **Quality Control Managers** ensure that the products made serve the needs of the users; these Managers will watch and record the results from signs, bins, and other materials made to assure they are consistent with the desired outcomes, making changes and revisions in design and placement where necessary.

G. **Distributors** set up the equipment throughout the school and make sure that it is used and maintained properly.

Once specific tasks have been assigned, teachers should work with students to operate their factory. Classroom time can be spent discussing what should be done (producing signs, posters, recycling collection equipment, for example) and how it should be done. Shop time or after-school time can be used to operate the factory.

With each group clear on its role and assignment, the class/factory should produce the needed signs, bins, etc. and put them in place throughout the school.

**DISCUSSION/QUESTIONS:** Once the project is complete, ask the following questions:

A. What were the major problems that your company encountered as it worked to manufacture its product?

B. How did you resolve these problems?

C. Did you finish your product on time? Why or why not?

D. How much would you have had to charge if you were selling it on the open market? (In order to do this, have students estimate labor costs, equipment rental fees, and profit margin and add these to the raw material costs.) What would happen if someone else sold the same product for less?

E. What changes, if any, would you make in your company?

F. How might you have lowered the cost of your product?

G. On the topic of business generally, ask your students their thoughts on the following:

1. Why do some factories shut down?

2. Discuss the benefits and drawbacks of capitalism.* What is it? Does it work? If so, for whom? (*"Capitalism" is an economic system in which all or most of the means of production and distribution are privately owned and operated for profit.)

3. Does the company as a whole benefit if its employees are happy? If so, in what way?

## VARIATIONS:

A. Older students can study labor history in America at the same time that they run their factory.

B. Enterprising classes can hold labor meetings and conduct contract negotiations between workers and management. Are there grievances by either side that need to be addressed? How can a compromise be reached? What might have happened if this situation had arisen in America one hundred years ago?

## FURTHER STUDY:

A. Assign students to interview parents or relatives that work in a manufacturing company. What do they do? How do their jobs relate to the jobs performed by students in their mock company? Are the jobs similar or different? Why? Ask them to report their findings in writing or as a presentation for class discussion.

B. Schedule a field trip to a local manufacturing facility where students can examine first hand the processes, structures, and organization required for this kind of business. (Suggestion: a local car manufacturing plant or a plastics recycling & remanufacturing facility.)

## ACKNOWLEDGMENTS:

Our thanks to Ben Hitchings for writing this activity.

# FOLLOW-UP SCHOOL AUDIT: HOW WELL ARE WE RECYCLING?

**Subjects:** Social studies, mathematics, language arts, environmental science, home economics

**Format:** One to multiple class periods in conjunction with student volunteer time at lunch and after school

**OBJECTIVE:** To assess the extent to which the school has reduced the amount of waste it regularly disposes of in its dumpsters, several months after the introduction of a recycling program.

**METHOD:** Students will perform a waste audit, using the same method they used for the initial "Performing A Waste Audit" activity (either have students conduct a one-day audit of classroom and/or food service waste, or have them examine and analyze the contents of school dumpsters). They will then assess degrees of participation and attitudes about the program by performing informal surveys of students, teachers, and staff.

**BACKGROUND:** After initiating a recycling program in your school, it is useful to assess how well you are doing. Data about waste stream reduction is good to have for several reasons: for your own information, so that you can improve your program as needed; to demonstrate the program's success to school officials and parents and to publicize the program; and to look for additional steps you can undertake to gain even greater waste reduction, e.g., by reducing at the source.

In addition, knowing the degree of participation and participants' attitudes about the program will help direct your educational efforts.

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## MATERIALS:

A. The waste generated in classrooms and food service areas

B. A scale for weighing materials

C. A washable plastic tarp

D. Gloves and goggles for dumpster audits.

E. Permission Slip (see end of activity)

## PROCEDURE:

A. Find out if parents and school administrators will allow actual dumpster audits. (NOTE: Parents who do not give their children permission to sort material may be assigned as counters and recorders -- see "Further Study" section, below.)

B. If approved, provide students with safety goggles and heavy gloves. Spread out a washable plastic tarp and have students dump the contents of garbage bags from the dumpster onto the tarp. Sort it into categories: paper, plastic, metal, organic, recyclable, not recyclable. Chart your results and **compare them with the results of the initial audit, from the activity in Part I, "Performing a School Waste Audit."** Publish them in the next recycling newsletter.

C. If dumpster sorting is not an approved activity, have students collect all the waste that they generate in one day in the classroom and store it in an agreed upon place so that maintenance staff will know not to throw it away. The next day, ask students to analyze what they generated: what percent was paper? Aluminum? food wrapping? Organic material? What could have been recycled? What need not have been generated? Compare these results with the initial audit and publish them in the next recycling newsletter.

Coordinate with Food Service staff to have students collect waste from the cafeteria at one lunch period. Place two types of clearly marked containers wherever trash cans are located: one for food waste and one for non-food waste. Make sure that this activity is announced to all students eating lunch both at the beginning and towards the end of the lunch period – explain the audit and the reason for doing it. Weigh the food waste and the non-food waste generated. Go through the non-food waste generated to determine how much of it could have been recycled. Compare the results with those from the initial audit and publish them in the next recycling newsletter.

D. Ask students to conduct a survey of school-wide attitudes towards the recycling program, interviewing students, teachers, and staff. Ask questions such as: do you recycle everything that you can? Would you carry an aluminum can to a recycling bin if it is a few feet away or would you put it in the trash can which might be closer? If you are not recycling, why not? If you are recycling but not very much, or are not recycling, what would it take to convince you to recycle more? Compile the results of your survey (number of people interviewed, percent that answered each question each way) and put them in the next recycling newsletter.

## DISCUSSION/QUESTIONS:

A. Has the overall quantity of garbage (waste sent to landfill or incinerator) declined since the first audit/audits?

B. Has the percent of recyclable material in the garbage declined since the first audit or audits? By how much?

C. What materials were thrown away that should have been recycled? How does this compare to the results of the first audit or audits? (Are they the same materials or different ones?)

D. How can you educate each other and the rest of the school in order to recycle those materials?

E. How many people say they are recycling regularly? How many say they are not? What are their reasons for not recycling, and what do they say would convince them to either recycle more (if they are now recycling less than they could) or recycle at all (if they are currently not recycling)? Discuss, analyze, and brainstorm plans to improve participation.

## FURTHER STUDY:

Get more scientific with participation rates:

A. Assign one or two students to count the number of students entering the lunchroom during a period of time, without the other students knowing what is happening (they can use a hand counter to record each time someone enters the room).

B. Assign several other students to monitor the trash cans, keeping track of the number of people who throw away something that is obviously recyclable into the trash can. Another person should keep track of the number of people who put non-recyclable materials in the recycling bins.

C. Calculate the percentage of people out of the total who entered the lunchroom (A, above) during that time who put (1) something that was obviously recyclable in the trash can and (2) something that was non-recyclable into the recycling bins.

D. Publish the results in your school's recycling newsletter.

## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for writing this activity.

## PERMISSION SLIP

On (date) ________________ your daughter or son will be participating in a study of waste generated by ___________________________ School. This will involve the handling of school garbage from dumpsters. Students will be provided with heavy gloves and goggles, we will coach them in safety procedures, and every precaution will be taken to ensure your child's safety. A faculty member will be present. We need your permission for your child to participate in this activity. If this meets with your approval, please sign the statement below, detach it, and return it to us by (date) _______________.

If you have any questions, please contact ______________________ at ___________________ School at (telephone #) _________.

Sincerely,

My child, ___________________________ has my permission to participate in the school waste audit to be conducted at ____________________ School.

______________________________ ________________________

(parent's signature) (date)

# PART II

## WE HAVE OPTIONS AND WE MAKE CHOICES

- *Bringing It Home*

# HOME WASTE AUDIT

**Subjects:** Science, social studies, environmental science, home economics, mathematics

**Format:** Individual homework assignment; students can produce written reports; an option is to have a class discussion (e.g., half a period or a whole period) to compare student findings; data can be compared and compiled into a class report

**OBJECTIVE:** Students will (1) relate some of the waste minimization concepts learned at school to the home, (2) teach these concepts to their families, and (3) reduce waste generated at home.

**METHOD:** Students conduct audits of the waste generated in their homes, chart their families' usual purchasing habits, and determine new practices which would generate less waste.

**BACKGROUND:** Currently, Americans live in a **disposable society** -- one where manufactured products are designed for a single use and are then disposed. Most Americans don't separate reusable or recyclable items from their trash -- they just put them all together, unsorted, on the curb for pickup. Currently, 73% of America's waste goes directly to landfills, 14% is incinerated, and only 13% is recycled. This way of disposing of waste is really quite recent. Until some 30 or 40 years ago, people routinely separated their garbage into different categories; very little was sent to landfills or incinerators.

People **reused** materials, such as pickle or mayonnaise jars, over and over. They didn't have throw-away milk jugs; milk came in bottles, which the milk company delivered and then picked up, cleaned, and refilled. Most food waste was **composted**, a process whereby organic material breaks down and is used to enrich soil. Materials like steel and aluminum, which are expensive to produce, were collected, melted down, and made into new items, in a process known as **recycling**.

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Recycling is an established means of managing and conserving resources. It is expensive and energy-intensive to extract new raw materials from the ground and shape them into new manufactured goods. Therefore, until recently, materials were always collected and recycled -- even old rags were collected from peoples' homes and used in the manufacturing of paper.

Waste **reduction**, however, is even more effective than recycling in managing and conserving resources. If a family goes to the local co-op and buys peanut butter in a glass jar they already have, one less glass jar has been made, which saves the energy and materials needed to produce that one glass jar. In addition, the family is **reusing** the glass jar they already had -- that jar stays out of the waste stream, doesn't fill up the landfill, doesn't have to be collected by recycling crews, doesn't use the energy it would take to remanufacture it into a new product.

In addition, Americans have somehow gotten into the habit of landfilling or incinerating **organic** waste -- yard waste or food waste that could naturally decompose and serve other organisms in the ecosystem. **Decomposition** is the process of breaking something up into its component parts. This process is part of the natural cycle that organic materials go through -- it can be called nature's recycling.

When food waste, yard waste, manure, and other biodegradable garbage is combined and exposed to air and water, bacteria efficiently break them down into compost, which can be added to soil to provide nutrients and a desirable texture. This is called **composting**. The texture of compost is usually good for both aeration and moisture retention because compost is usually granular, allowing water and air to move through it freely.

The purpose of this home audit activity is to inventory what is thrown away and what is purchased by a family for the home. Monitoring the family's trash for a week or so can be an eye-opening experience for students if they have never thought about what family members view as "trash." The activity will give students a baseline of data discussing with family members what can be done to prevent landfilling of otherwise recyclable and reusable material. It will also help clarify how waste can be reduced -- not generated in the first place -- by prudent buying alternatives.

The opportunities to compare student findings as a class will help individuals appreciate the differences among different family waste management practices. Students will see how individual preferences for certain products alter the amount of waste generated. These data can help students understand that **individuals** can make a difference.

## MATERIALS:

A. Food and non-food products found in the home and yard

B. Five audit charts included at the end of this activity

## PROCEDURE:

A. Go shopping with whoever usually does the shopping in the family. Using Chart 1 (at the end of this activity), list and describe the materials purchased by quantity and package size, packaging materials, and recycled content. You will need this information later to compare what is disposed of and to determine how materials could be packaged differently to produce less waste.

B. Using Chart 2, do an audit of kitchen cupboards and identify all of the disposable items, such as paper napkins, plastic utensils, and paper plates. Record quantities, frequency of use, preference by family member, etc. Finally, list reusable substitutes for each disposable product.

C. Referring to Chart 3, list materials that the family buys regularly. Which ones could be **reduced**? Which ones could be replaced by something that could be reused or recycled?

D. Using Chart 4 as a guide, inventory the family's trash once a day for a week, recording the amount of each material you find. What percentage of the total is recyclable? Compostable? Chart how much of each material you find and list ways to reduce the total amount.

E. With Chart 5, inventory the composting activities (or lack of them) in your household, asking questions such as: Is yard waste composted? Does the family leave grass clippings on the lawn? Does the family compost food waste, either in a backyard compost pile or in a worm bin (vermicompost system)? (See two related activities, "Striking It Rich with Classroom Composting" and "Vermicomposting.")

**RESULTS:** Ask students to write up their findings and their plans for reducing their households' wastes. Emphasize that no matter how well waste is being managed, there is always room for improvement. Assign at least 4 or 5 students to present their findings and their plans, and spend part of the class period discussing them. Ask students to prepare a written list of home waste reduction practices that **all** students can take home to their families.

## DISCUSSION/QUESTIONS:

A. What is the best way to buy peanut butter?

   1. Buy a brand new jar at the store, use the p.b., throw the jar into the trash, and then buy another one.

   2. Buy a brand new jar at the store, use the p.b., recycle the glass jar, and buy another brand new one.

   3. Buy a glass jar of peanut butter that is certified to be made from post-consumer glass; use up the p. b., recycle the jar, and buy another.

   4. Buy a glass jar made from post-consumer glass and use up the p. b. Save the jar and take it to a food co-op and fill it with bulk peanut butter.

B. Why is the option you picked the best one? Did you consider both energy use and waste reduction?

C. If you are buying vegetable oil in a plastic bottle, which of the plastic coding numbers should you look for on the bottom? Why?

D. What are good ways to save paper?

   1. Always use a sheet of paper on **both** sides before putting it in the recycling bin.

   2. Cut up paper used on one side and use it for memos and notes.

   3. Make xerox copies double-sided whenever possible.

   4. Photocopy some documents on the back of paper that has already been used on one side.

E. What are three good ways to manage food and yard waste?

ANSWERS:

A. 4

B. Because your container is made from **post-consumer** recycled glass, you help stimulate the market for recycled glass. And because you re-use the jar by taking it to the local co-op and filling it up with bulk peanut butter, you save the energy and materials which would have been used to make another glass jar.

C. Numbers 1 or 2 -- PETE and HDPE -- since these plastics are the plastics most often recycled.

D. All four options.

E. Leave grass clippings on the lawn, compost leaves, and compost food waste with worms or by composting it in a pile outdoors with other organic material.

**FURTHER STUDY:** Ask students to call a local food co-op to schedule a visit to learn how co-ops encourage customers to reduce waste while buying foods. Assign them to learn how the co-op is financed, what membership costs, what it does with waste food, and other information that relates to waste and cost reductions. Ask students to report their findings to the class.

## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for writing this activity.

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# CHART 1 - MATERIALS PURCHASED

| Product & Brand | Amount | Package Size & Material | Recycled? | Regular Purchase? |
|---|---|---|---|---|
| 1. EX: fresh squash | 1 lb | 4" x 4" styrofoam tray w/plastic wrap | No | Yes |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
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| 17. | | | | |
| 18. | | | | |
| 19. | | | | |
| 20. | | | | |

# CHART 2 - DISPOSABLE ITEMS

| Item | Quantity | Frequency Used | Who Uses? | Durable Substitute? |
|---|---|---|---|---|
| 1. EX: paper plates | 100 | 100 per month | Mom | washable china |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
| 7. | | | | |
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| 17. | | | | |
| 18. | | | | |
| 19. | | | | |
| 20. | | | | |

# CHART 3 - REDUCE AND RECYCLE

1. What materials are your family currently recycling?

2. How often?:

3. How much per week/month? (Numbers of items or pounds of material)

4. Which materials are already being reused?

5. List the materials from the first chart which your family buys regularly. Which ones could be eliminated, replaced by something that would produce less waste, reused, or recycled?

6. What recycling is available in your community? Is there curbside pick-up? Is there a drop-off center? (Call your City Hall if you're not sure)

7. If your family isn't recycling, or could easily recycle more, draw up a plan for recycling in your household.

# CHART 4 - TRASH INVENTORY

DAY 1: MATERIALS

DAY 2: MATERIALS

DAY 3: MATERIALS

DAY 4: MATERIALS

DAY 5: MATERIALS

DAY 6: MATERIALS

DAY 7: MATERIALS

1. What materials constitute the largest components of your family's waste stream?

2. Which of these materials are reusable, recyclable, or compostable?

3. Which of these materials can be reduced by changing buying or use practices?

# CHART 5 - YARD WASTE INVENTORY

1. Does your family compost yard waste?

    a. If yes, which materials (grass clippings, leaves, etc.)?

    b. What kind of compost pile do you have? (i.e., a pile, or are materials enclosed in some sort of bin? Specify what kind of bin.)

2. Does your family leave grass clippings on the lawn?

3. Does your family compost food waste, either in a backyard compost pile or in a worm bin (vermicompost system)? Specify which:

4. Does your family have a large, medium-sized or small amount of lawn to mow?

    a. Record how many bags of clippings are usually generated when the lawn is mowed (if your family bags the clippings).

    b. Does your house have many deciduous trees around it?

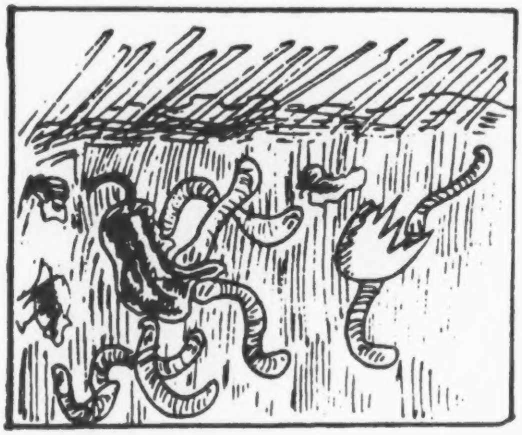
    c. If bagged, how many bags of leaves (and branches, nuts, etc.) are usually raked every fall, on average?

5. Make a plan, based on your family's needs/interest/space availability for dealing with yard and food waste generated.

# VERMICOMPOSTING:

**Subjects:** Biology, environmental science, science, English

**Format:** Individual students or teams over a month or the school year; science fair project; pilot for a school food composting program



**OBJECTIVE:** Students will learn about (1) the physical requirements for worm composting, (2) the biological organisms in addition to worms that participate in decomposition of organic matter, and the (3) maintenance, monitoring, and record-keeping procedures necessary to conduct a worm composting project (i.e., constructing or customizing bins; calculating the proper amount of bedding and preparing it; measuring food waste and adding it regularly to the bin; measuring decomposition rates, temperature, acidity, and moisture content, etc.).

**METHOD:** Students will build and/or acquire a suitable container for worm composting and conduct an in-depth study of composting as a recycling process. The procedures can be conducted at school and at home, with off-the-shelf or purchased materials.

**BACKGROUND:** Yard waste makes up about 20 percent by weight of the national waste stream, and it is now banned from landfills in states such as New Jersey. It will be banned from landfills in Ohio beginning in December 1993. Composting is a highly viable method for disposing of yard waste. Food waste, though a smaller portion of the waste stream at 9 percent by weight, can be composted with yard waste.

There are two types of composting: **aerobic** and **anaerobic**. The less popular method is anaerobic composting because it gives off strong odors. Anaerobic composting is used mostly with sewage sludge.

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Aerobic composting involves bacteria that require oxygen, referred to as aerobic bacteria. This is the common sort of composting that generally takes place in back yards, farms, and in municipal compost piles.

When compost piles are properly ventilated so that plenty of oxygen is circulating, aerobic bacteria thrive and break down materials. Ventilation is achieved by turning compost piles with pitchforks or larger equipment. When there is not enough oxygen, anaerobic bacteria start to move in and strong odors can develop. Acids are also created as byproducts of anaerobic composting. Sanitary landfills have limited oxygen circulation, so anaerobic composting often takes place there.

The essential ingredients of aerobic composting are **oxygen**, **moisture**, an **energy source** (here provided by garbage, which contains carbon compounds such as simple sugars, lignin, and cellulose), and **nutrients** (found in plant and animal tissue, manure, and fertilizers).

When these are combined, bacteria begin to multiply and, as a result, to give off heat. Various bacteria require different temperatures to survive - a newly formed compost pile is cool, and attracts **psychrophiles**, which live at temperatures between 30 and 50 degrees F. As the temperature rises to heights between 70 and 100 degrees F, **mesophiles** start to multiply, followed by **thermophiles**, at temperatures between 100 and 160 degrees F. At about 140 degrees F, antibiotics are created by the thermophiles, killing disease-causing microbes. The temperature of the compost pile usually becomes stable at about 158 degrees F for 3-5 days, and then drops down again to temperatures conducive to mesophiles. Finished compost is the temperature of the surrounding area.

Finished compost should be fluffy and crumbly, not sticky. It should be dark in color, but not black (black materials might contain too much acid). It should smell earthy, not rotten, and should match the surrounding area in temperature.

Other organisms in the compost pile include **fungi**, which break down tough materials such as cellulose (found in materials like paper) that bacteria leave behind. Also present is the **actinomycete**, a bacterium that forms colonies which look like gray cobwebs and which give the compost its earthy smell.

The **food chain** of the compost pile is also of interest. The bacteria consume organic matter, and may in turn be consumed by roundworms or protozoa. Fungi also consume organic matter, and they may be consumed by organisms such as beetle mites, which are then consumed by centipedes or ants.

Schools or city residents may decide to compost indoors. One effective type of indoor composting system makes use of the **redworm**, or **Eisenia foetida**. Composting with worms is called **vermicomposting**. Much of the following information is based on **Worms Eat My Garbage**, by Mary Appelhof.

Vermicomposting requires students to build a bin to hold the worms and organic materials, to control the environment so that it is conducive to worms and composting, and to measure variables such as moisture, weight of bedding, temperature, etc.

The best type of worms for vermicomposting are **redworms**. There are many other names for them besides the Latin name, **Eisenia foetida**; they include the vernacular names such as "red wiggler," "manure worm," "red hybrid," "fish worm," "dung worm," or "striped worm." Another type of worm suitable for composting is the **Lumbricus rubellus**.

These worms are available at bait shops or from the address on the bottom of the chart at the end of this unit. Worms found in an **outdoor** compost pile would probably be suitable for **indoor** vermicomposting, but there are definitely some worms found in the ground which are **not** suitable. For example, nightcrawlers, or **Lumbricus terrestris**, are good for the garden but not for the worm bin. These worms need a very large amount of soil and cannot survive bed temperatures above 50 degrees F.

Redworms are the best to use for several reasons. One reason is that they reproduce quickly and mate at any time during the year. Their population is limited in the worm bin by the amount of food available and by the amount of free bedding that has not already been converted into castings which worms excrete. They also deal well with whatever space is available and with the warm temperatures found within the average home.

Redworms reproduce by joining with mucus produced by the clitellum, a round band around the mid-section. Each worm has both ovaries and testes. When the worms join, sperm passes from each worm to the other's sperm storage sac. A cocoon later forms on the clitellum of each worm, the worm backs out of the cocoon as it hardens, and eggs and sperm are deposited into the cocoon as it passes over openings from the ovaries and the sperm storage sacs.

The cocoon seals itself, fertilization takes place inside of it, and later two or more little worms hatch out of one end of the cocoon. It takes redworms from four to six weeks to mature enough from hatching to start reproducing.

# MATERIALS:

A. FOR AN OFF-THE-SHELF BIN:

Obtain a ready-made container measuring approximately 1' high x 2' long x 3'wide, along with a lid or a black plastic cover. (Width, not depth, is more important for the most productive worm composting.) Students may adapt materials they already have on hand to make worm bins; for example, a plastic container can be used. One essential is that holes be drilled through the bottom of the container, whatever the material. Students could replace the glass bottom of an aquarium with a piece a wood that has holes drilled in the bottom.

- Properly sized container with lid/cover and holes drilled in the bottom
- Newspaper
- A plastic milk jug for measuring water
- Water
- One or two pounds of redworms, depending on the size of the bin; worms available at bait shops or at the address at the end of the unit
- Two handsful of soil
- Bathroom or utility scale
- Large clean plastic or metal container for mixing bedding
- Sheet of black plastic -- a household garbage bag will do -- to cover the bin and keep out light
- Laboratory stick thermometer that can measure temperatures up to about 170° F.
- 2 boards, or four bricks, or other comparable items to place under the bin so that the bottom will receive sufficient air

- sheet of plastic, or large flat garbage bag, or several unfolded newspapers to put under bin in case water or bedding leaks through the holes

B. FOR BINS THAT STUDENTS CONSTRUCT

1. LARGE WORM BIN: (You will need all of items listed above for an "off-the-shelf" bin **except** for the "properly sized container." You will also need the additional materials listed below.) NOTE: Since the most important characteristic for the container chosen is shallowness -- the width, not the depth -- students should check the square footage carefully and the relative dimensions. If the bin is too deep, bedding and worms will become densely packed on the bottom, reducing air flow and encouraging anaerobic composting. This will defeat the purpose of the bin and make it malodorous.

   For a large box, 1' high x 2' long x 3' wide handling 6 pounds of garbage per week:

   - 2 pieces 5/8" CDX (exterior) plywood (35-5/8"x12"), or #2 pine boards, or scrap lumber
   - 2 pieces 5/8" CDX plywood (23-3/8"x12"), or scrap lumber
   - 1 piece 5/8" CDX plywood (24"x36") or scrap lumber same size
   - 38 2" nails (ardox nails are particularly good, because the spiral shape holds wood together that may be alternately wet and dry), hammer, drill with 1/2" bit
   - 2 boards, or four bricks, or other comparable items to place under the bin so that the bottom will receive sufficient air
   - sheet of plastic, or large flat garbage bag, or several unfolded newspapers to put under bin in case water or bedding leaks through the holes

2. SMALLER WORM BIN: See common list of items under "Large Worm Bin," above. In addition you will need:

   For the smaller bin, 8" high x 2' long x 2' wide handling 3 pounds of garbage per week:

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- 4 pieces 5/8" CDX plywood (23-3/8"x8")
- 1 piece 5/8" CDX plywood (24"x24")
- 36 2" ardox nails (ardox nails are particularly good, because the spiral shape holds together wood that may be alternately wet and dry), hammer, drill with 1/2" bit
- 2 boards, or four bricks, or other comparable items to place under the bin so that the bottom will receive sufficient air
- sheet of plastic, or large flat garbage bag, or several unfolded newspapers to put under bin in case water or bedding falls out of holes

## PROCEDURE:

A. Assembly of Large and Smaller Worm Bins

1. Assign students to build the worm bin. Divide into small sub-groups (2-3 people) to build worm bins and do related experiments. They will later report to the whole group.

2. Assemble the bin:

    a. Start by nailing sides together in a rectangular shape, about 4 nails per side. Then attach the bottom to the sides by using 5-7 nails per side. To assure proper air circulation and drainage, drill twelve 1/2" evenly spaced holes in the bottom. (See chart).

    b. Note: if the worm bin is made of wood, students could experiment by lining the sides of the bin with plastic garbage bags secured into place by thumbtacks. This may help the wooden bin retain moisture.

## B. Preparing the Bedding and Worms -- Off-the-shelf and Large and Small Bins

Worms need an environment that has approximately the same moisture content as their bodies, 75%. This is regulated by weighing the shredded newspaper and adding three times as much water.

1. Fully open sheets of newspaper and tear lengthwise down the center, then gather two halves and tear lengthwise again, and repeat this process five or six times for each section. You should have strips that are one to three inches wide.

   For the smaller worm bin (8" x 2' x 2'), you will need from four to six pounds of dry newspaper strips. You'll need from nine to fourteen pounds for the larger bin (1' x 2' x 3'). Measure newspaper on a household utility scale, or on a bathroom scale by first weighing yourself and then weighing yourself holding a plastic bag full of dry newspaper strips. The difference between the two weights is the weight of the newspaper.

2. Calculate the amount of water needed by multiplying the weight of the newspaper by three. Remember that a pint of water weighs a pound, so a gallon of water (eight pints) weighs eight pounds.

3. Place about half of the newspaper in the mixing container, add about half of the required amount of water to dampen the paper, and mix. Then add the two handsful of soil and the rest of the newspaper and water. Mix well, and then empty into the worm bin and distribute the newspaper evenly.

4. Now, gently place the worms on top of the bedding, spreading them around evenly. Keep bin uncovered -- within a few minutes, worms will move down into the bedding to avoid light.

   Worms prefer darkness; even though they have no "eyes", they do have sensory cells on their skin which detect light. However, they are more sensitive to a broad spectrum wavelength than to a narrow spectrum. This means that you could take the worms into a photographic darkroom and observe them there under the red light - they would stay closer to the surface of the worm bin.

NOTE: Despite the holes in the bottom of the bin, the worms will stay in the bin because they do not like light.

## C. Burying and Observing Decomposing Food Waste

What kinds of food waste can be fed to the worms? Just about any waste left over from school lunches can be added - bread, fruit, vegetables, cheese, pasta etc. Materials to exclude are meat, bones, and non-foods such as plastic wrap or rubber bands. Meat and bones **can** be composted, but these materials take a long time to decompose and their presence in a worm bin may attract rodents.

Note: if worm system is used at home, make sure that cats do not use the system as a litter box -- cat feces can contain a disease organism called **Toxoplasma gondii** which is harmful to humans, especially pregnant women -- fetus brain damage can result from contact with this organism.

1. Have a data sheet for recording all variables (see chart titled "Sample Vermicomposting Data Sheet" at the end of the activity).

2. Weigh worms before placing in the bin, and record weight

3. Bury food waste in a pattern (see chart at end of activity). It is possible to overload the system by adding too much food waste, so bury waste via the pattern, keeping track of the weight and placement of food buried. If you get back to the first burial site and notice that food has decayed very little, do not add food waste until that food has decomposed enough to make room for the new food. Also, if you notice a strong odor to the bin, this may indicate that the system is being overloaded.

4. Food waste can be added daily, every other day, or weekly.

5. Take the temperature of the worm bin once per week to determine the variations that occur while food is being composted. Use a laboratory stick thermometer which can measure temperatures up to about 170° F. How much time does it take to observe a noticeable change in temperature? What does the temperature indicate about the type of bacteria currently thriving?

6. Notice where worms tend to congregate -- do they seem to prefer certain foods to others? Do smaller pieces of food waste tend to break down faster than larger ones? Why?

7. Use pH paper to test the acidity of the compost bin once per week. Are there changes based on the foods added? Note these.

8. Bury different materials in different spots and chart their rates of decomposition; i.e., does a banana peel tend to decompose more or less quickly than a coffee filter? Bury non-foods, too, such as a plastic bottle, and chart its **rate** of decomposition.

   Students measure these variables:

   a. Temperature over time

   b. Acidity of material over time

   c. Number of worms over time

   d. Weight of food waste as it is added

   e. Decomposition rates of food waste buried in a specific pattern and charted

   f. Amount and frequency of water added

   g. Compare the rates of decomposition of a banana peel vs. coffee grounds

D. Directions for "harvesting" humus from the worm bin:

After a period of 3-6 months, depending on the size of the container (a larger container would probably go for 6 months and a smaller container for less time), you will notice that the food and bedding in the worm bin have almost completely been transformed into worm castings, the nutrient-rich waste material that worms excrete. Now it is time to harvest the humus and change the bedding.

**(NOTE: BE SURE TO MONITOR YOUR BIN AND HARVEST IT WHEN IT BECOMES MOSTLY CASTINGS. THE WORMS WILL STAY IN THE BIN IF THEY HAVE PROPER BEDDING, MOISTURE, TEMPERATURE, AND FOOD. WITHOUT THOSE THINGS, THEY MAY LEAVE THE BIN IN SEARCH OF BETTER CONDITIONS.)**

1. The first step is to assign a group of students to prepare new bedding for the worms while another group of students harvests the humus. (See Step A under the "Procedure" section, earlier in this activity, for preparing bedding.)

2. Now put down a sheet of plastic (e.g., a drop cloth, a plastic table cloth, etc.) for the second group of students. Spread it out in an open area (the floor is probably the best choice) to approximately 4' to 6' square in size. Dump the entire contents of the bin out onto the plastic sheet -- worms, food, remnants of bedding, and castings.

3. Sort the material into several (six to nine) cone-shaped piles (wider at the base and narrower at the top). Put a bright light over them, or at least make sure the room is well lighted. Worms dislike light, and so they will burrow down deep into the pile to avoid it. Gradually scoop off materials from the tops of the piles -- you will be able to watch most of the worms bury themselves deeper into the pile. Put the humus (worm castings) in a container -- you can use it later to plant houseplants. Put the worms in a second container, and put any uncomposted food waste or old bedding into a third container.

4. When you reach the bottom of the piles, you will find a lot of worms. Put them in the container with the others. When all of the piles are sorted, add the container with the uncomposted food waste and old bedding to the bin where the first group of students has placed the new bedding.

5. Then dump in all of the worms. Allow the bright light to shine on them for a few minutes so that they bury themselves in the new bedding. Then add some fresh food waste, put the cover on your worm bin, and you are ready to go for another 3-6 months.

## DISCUSSION/QUESTIONS:

A. Describe the following:

    1. Similarities between recycling a material such as an aluminum can and the decomposition of a material such as leaves, and

    2. Differences between those two processes

B. What are the differences in rates of decomposition among the following materials in a composting system: banana peel, coffee filter, plastic bottle? Why do their rates differ?

C. If you were going to build a worm compost system, what materials do you think would be best for constructing the bin? Why?

D. What are the main ingredients of a composting system?

E. Which is **most** important? (Choose one.)

1. Building more landfills and incinerators to dispose of society's waste.
2. Recycling as much of the waste stream as possible.
3. Reducing the amount of waste produced in the first place.

(ANSWERS)

A-1. Similarities between recycling an aluminum can and the decomposition of leaves: both processes allow the materials to be broken down and then used again (an aluminum can is melted and then re-processed into a new aluminum can; and leaves are broken down and then used as nutrients for other plants).

A-2. Differences between recycling an aluminum can and the decomposition of leaves: if leaves fall on the ground, eventually they will decompose; an aluminum can requires special equipment and a certain amount of energy in order to be recycled. Also, leaves are broken down and their component parts used - they do not directly become new leaves - whereas an aluminum can is reprocessed directly into another aluminum can.

B. Banana peels decompose quickly, being 100% organic. Coffee filters take a little longer, and plastic may never decompose.

C. It would be best to build the compost bin out of plastic or other moisture-retaining materials, so that it will retain moisture well. A wooden bin could also be lined with plastic sheeting for good moisture retention.

D. A vermicomposting system's components include the following:

1. A physical structure - the box;

2. Biological organisms - the worms and other denizens of the compost world;

3. Controlled environment - temperature, acidity, moisture; and

4. Maintenance procedures - preparing the bedding, burying garbage, separating worms from castings, using castings.)

E. Number 3, reducing the amount of waste generated in the first place.

# FURTHER STUDY:

A. Assign students to produce a newsletter for family, friends, community about research done, conclusions reached, applications in the school and community. Include an invitation to view the students' work.

B. If possible, visit a municipal or commercial composting operation -- observe the process on a large scale.

C. The class could also contact/visit any local composting groups (such as a county Cooperative Extension Service). They can provide students with information to take home about back yard composting.

D. Assign students to conduct a cafeteria food-waste audit:

1. Get the permission of Principals and Food Service employees to take a period of 2 to 5 days to collect food waste separately from other waste.

2. Set up empty trash cans clearly labelled "FOOD WASTE" next to the trash cans in which students normally dispose of lunch waste.

3. Either weigh the cans before and after they are filled, or find out the volume each can holds.

4. Announce the test in homeroom or the period before lunch so that students and teachers know what to expect. Announce it again as a reminder during the actual lunch.

5. Assign two or three students to monitor the trash cans at the close of each meal. Students will have to ensure that all food waste is put in the food waste cans and all non-food waste is put in the normal trash cans (or recycled, if appropriate).

6. Students then weigh the cans or calculate the volume of waste by measurement.

7. At the end of the test period, compare the weights/volumes of the food waste generated on the test days, take the average, and then extrapolate from that the amount that will probably be generated in a week, a month, and a year.

   Once the food audit is complete, 2 - 3 students should be assigned to build a worm bin (or several could be built to compare results from different composting practices) to study the decomposition of food waste.

E. A plant biology activity could be done with two identical sets of potted plants. Add some of the finished, composted worm castings (minus worms) to one of the sets, but otherwise treat the two identically, and observe any resulting differences in the health/growth of the two.

F. For English class, ask students to write essays on how they vermicomposted and what it means to them and to the environment. They could even write sonnets about the worms if they felt so moved! Students could also prepare a flyer for community distribution describing class research and recommendations for home composting.

G. Classes might want to perform desensitizations of students with aversions to worms. Many students find organisms like insects, snakes, and worms distasteful or disgusting, so it might be helpful to take some time to explain the necessary interconnectedness of living systems and the role that these species play. Worms, for example, play an important role in soil productivity by breaking down organic waste and converting it to a nutritious and well-textured soil amendment.

H. A team of students could design and run an ongoing cafeteria composting project. They would also probably have to do some educating and desensitizing of students, faculty and staff who might have mixed feelings about worms in the cafeteria.

I. Do a waste audit at home and measure how much food waste the family produces in one week.

J. Build a bin at home and start to vermicompost.

K. Use information learned at school to start composting yard waste, an activity supported in many states under recent laws; this activity actually ties into civics classes, since it involves compliance with a state mandate. Students can investigate the status of their city's composting activities. If composting is not yet underway, students could investigate why. Are there barriers? Has no one ever introduced the idea? Students should contact local City Council members and attend Council meetings where environmental agenda items are being discussed or can be introduced. Afterward, they can report their findings to the class.

## SOURCES:

Applehof, Mary. *Worms Eat My Garbage.* Kalamazoo, MI: Flower Press, 1982.

Golueke, Clarence. *Biological Reclamation of Solid Waste.* Emmaus, PA: Rodale Press, 1977.

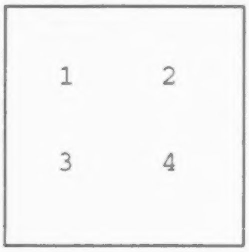
## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton for writing this activity.

## SAMPLE VERMICOMPOSTING DATA SHEET*

Date bin was set up:
How many worms? (In pounds or number of worms):
Kind of bedding used:
Dimensions of the worm bin:
How many people will be contributing to the food waste?

Draw the worm bin below, including its dimensions, and assign numbered plots to its surface so that you can track the decomposition of food placed in each numbered area:



| Date | Day | Weight of Food | Total Food Wt. to Date | Amount of Water | Buried in Site #: | Notes |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |

Harvest date:
Total Days:
Worm weights or numbers:
Total weight of food waste buried:
Weight of uneaten food:
Average weight buried per day:
Average temperature per day:
Average temperature where bin kept:
Temperature range where bin kept:

---

*Based on a graphic from Mary Appelhof's *Worms Eat My Garbage*, Kalamazoo, MI: Flower Press, 1982.
To order worms from Mary Appelhof, write: Flowerfield Enterprises, 10332 Shaver Road, Kalamazoo, Michigan 49002; Telephone 616/327-0108.

# WHAT'S HAZARDOUS AT HOME?

**Subjects:** Health, science, social studies, English

**Format:** Teacher-led discussion with the class

DANGER!!
WARNING!
KEEP AWAY FROM CHILDREN

**OBJECTIVE:** To teach students (1) that some household products may be harmful if handled and disposed of improperly, (2) where in the home such materials may be stored, (3) how to prevent themselves and others (e.g., younger brothers and sisters, friends, and relatives) from being harmed by such household hazards, and (4) if contact occurs, where to call for help.

**METHOD:** By questioning students, assigning students to draw floor plans of their homes, teaching them to look for warnings on labels of containers of hazardous materials, and conducting related activities, teachers help students to learn about harmful products in the home and how to avoid harm from them.

**BACKGROUND:** Consumers generally have little information about the long term effects of chemicals contained in common home and garden products. Many products and chemicals that were once considered "harmless" have now been linked to health problems, due to exposures over long periods of time. These health effects can be as mild as fatigue and headaches or as serious as cancer. A great many such products are stored in the home: they pose a serious health threat to children and others who are unaware of their potential for harm.

A substance classified as hazardous is required to bear labeling with warning statements and safety information if it is packaged for or intended for use in or around the home. The U.S. Consumer Product Safety Commission has established specific labeling requirements; however, labels required for various hazardous substances differ.

This, in addition to the considerable amount of label information required, can make it very difficult to determine how to use, store, and dispose of a product safely.

## MATERIALS:

- Packages and labels from potentially hazardous household products or sample products from the accompanying list entitled "What's In Your House?"
- Call the local Poison Control Hotline and ask for their information packet; photocopy appropriate sections for students.
- A word list (teacher developed) from the products or labels you bring in: it would include terms such as "poisonous," "harmful," etc.

**PROCEDURE:** Explain to students that there are products we use at home that may be hazardous if not handled and disposed of carefully. Explain that hazardous means dangerous and that hazardous substances are likely to cause harm to the environment or to humans because they are either toxic (poisonous), flammable (quickly burnable), reactive (explosive), or corrosive (substances that rapidly eat into or dissolve away what they touch).

A. Ask where at home they might look to find some of these products that require careful handling.

B. Ask each student to draw a map -- called a floor plan -- of his or her house/apartment and find where the storage areas are. (The drawing needn't be elaborate; tell students simply to include all the rooms, basement, garage, attic, storage shed, etc.).

1. Have each student draw a floor plan of his or her house and garage.
2. Project and hand out copies of the overhead (at the end of the activity) entitled "What's In Your House?" Go over the list with students, identifying and describing the less familiar products such as antifreeze, paint strippers, varnishes, and drain cleaners. Students may be more familiar with brand names of particular products.
3. Using the previously drawn floor plans, ask students to mark where their listed products may be found.

4. Show students packaging and labels from a number of products that you have brought in from the list.

C. Then, ask students where on a label or package can they find out whether a product might be harmful? What will the package or label say? (Package or label may say "Danger/Poison," "Warning," "Caution," or "Keep out of the reach of children," and then will list the possible harmful effects of the product.)

D. Ask students how and where such products should be stored. Ask students to draw an arrow on the floor plan showing where hazardous waste materials should be moved for safety.

E. Do the students know how their families can get rid of harmful products no longer needed without harming the environment or other people? (For answers, call the local health department to find out about disposal procedures and other related issues.) Tell the students that you will give them a handout for their family with this information on it.

F. Next, ask the students how many of them have younger brothers, sisters, relatives, or friends.

How could you help them if you found one of them eating or drinking something from the list we've been talking about? (By calling the local Poison Control Center, you can find out exactly what is in any of the products so you can tell the doctor. The doctor can then prescribe the correct antidote.)

How and where should the products on the list be stored **so small children can't get into them?**

G. Finally, ask students to take home the marked floor plans, the list of potentially harmful household products, and the information about safe disposal of them to share with their families.

**DISCUSSION/QUESTIONS:** As a review following the lesson or later in the week, ask students the following:

A. What are the four categories of hazardous substances?

B. What can you do if you have pesticides in your home that you no longer want?

C. Where should you look first to find out if a household product is potentially harmful?

D. What words do you see on a package that indicate that the product is dangerous? What do they mean?

E. What should you do if you find someone eating or drinking something harmful or poisonous?

F. What is an antidote?

## SOURCES:

Special thanks to Julie Sellick and John Conroy, Washington State Department of Ecology, for help with this activity.

Dyckman, Claire, et al. *Sleuth: Educational Activities on the Disposal of Household Hazardous Waste*. Seattle, Washington: Toxicant Program, Report No. 10, Water Quality Division, August 1982.

Schwartz, Ann. "Poisons In Your Home: A Disposal Dilemma," *Audubon*, May 1987, pp. 12-16.

Seymour, John, and Herbert Girardet. *Blueprint For A Green Planet*. New York: Prentice Hall, 1987.

Toteff, Sally and Cheri Zehner. *Toward Hazardless Waste*. Seattle, WA.: Seattle-King County Health Department, 1985.

## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology for permission to adapt this activity from *A-Way with Waste*.

# WHAT'S IN YOUR HOUSE?

**Potentially dangerous household wastes might be found in many places in the home. Some examples are listed below. Many of these products have environmentally safer alternatives. Contact the state's EPA Public Interest Center for information about household hazardous wastes and environmentally friendly substitutes. In addition, call the local Poison Control Hotline, and local Health Department with questions about safety or disposal:**

PET FLEA COLLARS

FLOOR POLISH

TOILET BOWL CLEANERS

ROACH SPRAY

SLUG BAIT

LAUNDRY SOAP

PAINT THINNER

MILDEW PROOFING

WEED KILLERS

LACQUER THINNER

OIL

WOOD PRESERVATIVES

ANTIFREEZE

RAT POISON

BRAKE FLUID

NO-PEST STRIPS

OIL BASED PAINT

BATTERIES

DRAIN OPENERS

STAINS/VARNISHES

ENAMEL PAINTS

FURNITURE POLISH

PAINT STRIPPERS

MOTHBALLS

ROOM DEODORIZERS

DISINFECTANT CLEANERS

OVEN CLEANERS

POWDERED BLEACHES

GLASS AND WINDOW CLEANERS

SCOURING POWDER

# PRODUCT DISPOSAL OPTIONS

A. Keep all chemical wastes out of the reach of children.

  - Read the label before handling any household chemicals.
  - Household wastes should not be mixed together for disposal.

B. Pesticides and Wood Preservatives: Pesticides should not be disposed of in the trash can or down the drain. Call your local health department district office or local Poison Control Hotline for recommendations.

C. Automobile Oil: Recycle at local gas station or call the local County's Recycling Coordinator to learn the locations of participating oil recyclers.

D. Antifreeze: Do not pour antifreeze into storm drains or sewers as these may be directly connected to streams. Call the local County Recycling Coordinator to learn how and where to recycle antifreeze.

E. Paint Solvents: When possible, reuse paint solvents by letting the paint sludge settle and reusing the solvent. If solvent is not reusable, call the local Health Department to learn how to dispose of it safely.

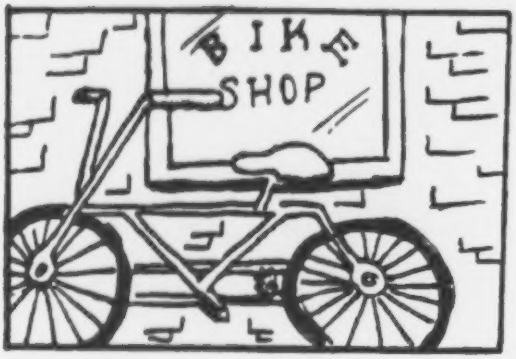
F. Paint: Some charities accept excess paints. Again, call the local County Recycling Coordinator to learn proper disposal and/or recycling/reuse options. Some counties have a periodic collection of household hazardous wastes.

G. If you have questions about disposal of these or any other materials not listed here, call the local Health Department in your community.

# BIKES AND BY-PRODUCTS

**Subjects:** Science, physical science, social studies

**Format:** One class period



**OBJECTIVE:** Students will learn (1) what by-products and hazardous wastes are, (2) how manufacturing generates them both, (2) what raw materials go into and result from the production of an item as familiar as a bicycle, (3) how to think about objects as the result of a process that very often begins with digging up natural resources and then shaping them into new chemical forms, and (4) appropriate ways to reuse or recycle old bicycles.

**METHOD:** Students will examine an actual bicycle in class during the discussion, as well as refer to a drawing of bicycle parts and related raw materials and wastes generated.

**BACKGROUND:** Sometimes making the things that we want, such as bicycles, creates things that we don't want, such as hazardous waste.

## MATERIALS:

- Bicycle -- select a student volunteer to bring one to class
- Diagram of "Bicycle Materials, Wastes & By-products" (see diagram following this activity: it is suitable as both an overhead master and as an original for making student handouts)

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# PROCEDURE:

A. Ask the students how many of them have bicycles.

Of what are the frames made?

How about the tires?

The handle bar grips?

Where are the metal and rubber and plastic that go into bicycles made? (In mills and factories that transform raw materials such as petroleum, bauxite and iron ore into bicycle components.)

B. Then ask the students what makes their own bikes special -- different from others?

How many different colors of bikes do we have?

Whose bike is shiny?

What is the shiny metal on bikes called?

C. Ask them what natural resources are used in making bikes? (Iron; petroleum, for plastics, synthetic fibers, and synthetic rubber; petroleum distillates for paint and paint solvents; bauxite for aluminum; chrome; coal for coke to smelt the iron ore into steel; and many others.)

D. Next, ask what had to happen to the natural resources before they could be used to build a bike? (They had to be processed mined or extracted, transported, and then transformed in factories.)

Direct the discussion from here with the aim of realizing that when natural raw materials are processed, by-products and waste -- some of which may be harmful -- are produced.

E. Ask the students what by-products are. (For example, what by-products are produced when you burn wood and paper in your fireplace or woodstove at home?)

Are some of these by-products harmful? Which ones? Why?

What kinds of things might be by-products from the building of a bicycle?

F. Next, distribute the "Bicycle Materials, Wastes and By-products" and ask students to compare it to the bike that has been brought to class. Guide students in identifying the bike's component materials (steel, synthetic rubber, plastic, chrome, synthetic fibers, aluminum, paint, etc.) Then, by referring to the diagram, point out some of the by-products and wastes resulting from the manufacturing of these components.

G. Explain that some of the by-products and wastes from making a bike are hazardous. Discuss what hazardous means. (Note: Hazardous means dangerous. Hazardous wastes are likely to cause harm to the environment or humans because they are either toxic [poisonous], flammable [ignitable, highly burnable], reactive [explosive], or corrosive [substances that rapidly eat into and/or dissolve what they touch.])

H. Ask students whether this means that they will become ill from handling or riding bikes. Why? Why not?

What happens to the hazardous by-products and wastes produced when bikes are made? (NOTE: Some are captured and recycled for industrial reuse. Some are captured and disposed of in hazardous waste disposal sites. For the closest hazardous waste disposal site in the Greater Cleveland area, call the Cuyahoga County Planning Commission, 216/443-3700. Some escape into the air and water, while others are dumped illegally.)

I. Then, ask the students how hazardous wastes and by-products should be managed. Why is it important to use great care in disposing of these wastes and by-products? (Because hazardous wastes and by-products are made when bikes are built, should we stop making bikes? Why? Why not?)

What should we do?

What are some other things we use that might also produce hazardous by-products when they are made?

J. Ask students to bring to class any news item they have heard recently about hazardous wastes. What kind of wastes were involved? From what were they made? Why are they dangerous?

K. What is an appropriate way to reduce waste from a bicycle that is no longer serviceable? (For example, it could be taken apart and some scraps could be recycled -- such as a steel frame -- while others could be reused, such as nuts and bolts holding parts together. Bikes that have been outgrown can be passed on to younger children, sold at a garage sale, donated to charitable organizations for repair and resale, etc.)

## FURTHER STUDY:

A. Invite the students to think about other manufactured items -- watches, baseballs, furniture, tape players, etc. -- and the materials from which they are made. Which are hazardous? Have they seen warning about hazards materials on them? (For example, smoke alarms have low-grade radioactive waste parts and are to be returned to manufacturers for disposal.)

B. Take students on field trips to manufacturing sites so that they have an opportunity to see an item "in process" -- most preferable would be to take them through the various manufacturing stages and the by-products produced: e.g., a steel mill, to see the processing of iron ore into steel; a sheet rolling plant to see the shaping and forming of material that will become bike fenders; a chroming facility to observe the plating process; a tire manufacturing site to observe tire manufacture; a plastics and injection molding plant where plastic parts are molded into bicycle components.

C. Ask students to investigate what the following fabric materials are made from and what by-products their manufacture produces: polyester, rayon, nylon, acrylic, silk, cotton, and wool. Do any of them produce hazardous wastes?

## SOURCES:

Special thanks to John Conroy, Washington State Department of Ecology, for help with this activity.

## BIBLIOGRAPHY:

Nemerow, Nelson. *Industrial Solid Waste.* Reading, MA.: Ballinger Publishing, 1983.

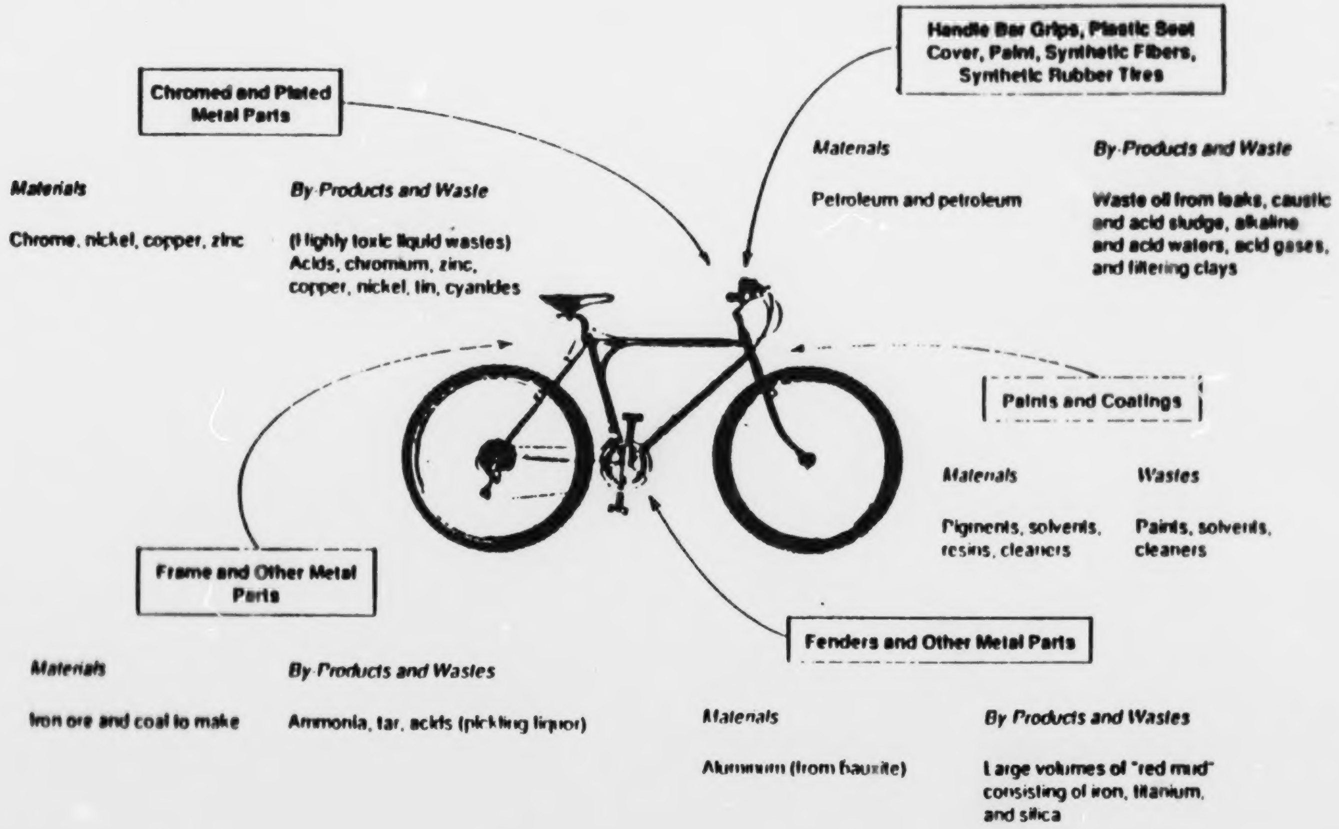
Nemerow, Nelson. *Industrial Water Pollution.* Melbourne, FL.: Kreiger Publishing, 1988.

## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology's for permission to adapt its

activity, "Bikes and By-products" from its publication, *A-Way with Waste*.

## BICYCLE MATERIALS, WASTES, & BYPRODUCTS



**Chromed and Plated Metal Parts**

| *Materials* | *By-Products and Waste* |
|---|---|
| Chrome, nickel, copper, zinc | (Highly toxic liquid wastes)<br>Acids, chromium, zinc, copper, nickel, tin, cyanides |

**Handle Bar Grips, Plastic Seat Cover, Paint, Synthetic Fibers, Synthetic Rubber Tires**

| *Materials* | *By-Products and Waste* |
|---|---|
| Petroleum and petroleum | Waste oil from leaks, caustic and acid sludge, alkaline and acid waters, acid gases, and filtering clays |

**Paints and Coatings**

| *Materials* | *Wastes* |
|---|---|
| Pigments, solvents, resins, cleaners | Paints, solvents, cleaners |

**Frame and Other Metal Parts**

| *Materials* | *By-Products and Wastes* |
|---|---|
| Iron ore and coal to make | Ammonia, tar, acids (pickling liquor) |

**Fenders and Other Metal Parts**

| *Materials* | *By-Products and Wastes* |
|---|---|
| Aluminum (from bauxite) | Large volumes of "red mud" consisting of iron, titanium, and silica |

Figure from the Washington State Department of Ecology's activity, "Bikes and By-products" from its publication, *A-Way with Waste*.

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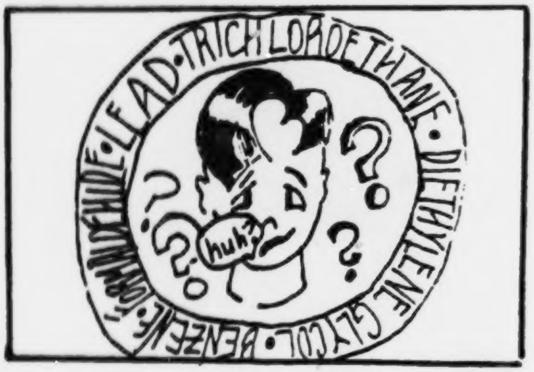
# HAZARDS IN YOUR HOUSE

**Subjects:** Science, environmental science, chemistry, home economics, industrial arts, health

**Format:** Home assignment plus 2 class periods



**OBJECTIVE:** Students will learn to (1) distinguish between a **hazardous substance** and a **hazardous waste**; (2) inventory, identify, and classify common hazardous substances in the home; (3) estimate the total amount of hazardous substances present in the community's households, and (4) minimize the number of hazardous substances by choosing safer alternatives.

**METHOD:** Students use sampling methods to estimate the amounts of potential household hazardous waste in the community.

**BACKGROUND:** In order to accomplish a number of common household tasks efficiently and effectively with minimum effort, our society uses many products which contain hazardous substances. In the course of performing tasks such as spraying yards and cleaning homes, hazardous waste is generated. Hazardous substances are chemicals that are dangerous to human health and/or the environment. Hazardous wastes are solids, liquids, or gases that can be harmful to human beings and/or the environment if not handled properly. The United States Environmental Protection Agency categories hazardous substances and wastes into four groups: toxic (poisonous), reactive (can explode or react violently if exposed to air or water), ignitable (able to catch fire), and corrosive (gradually dissolves other materials or containers). You can assume a household product is hazardous if the label mentions words like "pesticide," "caustic," "acid," "flammable," "warning," "danger," "poison," or "keep away from heat or open flames." The average home contains numerous products that are potentially hazardous if stored or disposed of improperly.

Although household hazardous wastes are exempt from the federal laws governing hazardous waste disposal, they are nevertheless a threat to the environment. It may seem acceptable for individual households to throw away small quantities of hazardous substances, but the cumulative impact of this habit can create serious environmental problems. Ground disposal (e.g., burying) of hazardous wastes can damage plants and contaminate water resources. Improper disposal in wastewater systems (e.g. pouring down drains) can damage pipes and eventually damage sewage treatment equipment or home septic tank systems since both of these processes are dependent on the actions of microbes for the breakdown of wastes.

Hazardous substances which are not reusable or recyclable should be taken to a household hazardous waste collection center or an "amnesty day" collection center for proper disposal (call the County Recycling center for information about local amnesty programs). However, the best way to manage household hazardous waste is to reduce consumption and use of products containing potentially hazardous substances and replace hazardous products with nonhazardous ones.

## MATERIALS:

- Recent community population estimate
- "Product Labels" transparency, "Data Collection" form, "Know Your Home" sheet, "Safer Alternatives sheet" (one each per student)

## PROCEDURE:

A. Day 1: Define the terms "hazardous substance" and "hazardous waste" and review the four major categories of hazardous wastes and substances. Ask students to name products in their homes which are examples from each hazardous waste category.

Project the "Product Labels" transparency and review the components of product labels.

Distribute copies of the "Data Collection" form and "Know Your Home" sheet. Instruct students to collect data about hazardous substances in their homes. Tell them to examine the labels of products in their homes to identify hazardous substances listed on the Know Your Home sheet. Explain that for each product, the following information should be recorded on the "Data Collection" form: (a) name of product, (b) product use, (c) name of potentially hazardous substance(s) in the product, (4) hazardous waste category of the substances (toxic, reactive, ignitable, corrosive), (5) estimated volume of product in the container, and (6) concentration of the substance (% of each hazardous substance contained in product). Remind students to check kitchens, bathrooms, laundry rooms, utility rooms, garages, closets, and hobby or garden areas for potentially hazardous products.

B. Day 2 Ask students to share and discuss their findings. Compile a list of potentially hazardous products found in the students' homes.

To help students understand how to use sampling to make estimates, first ask them to estimate the number of households in the community using population information and assuming an average of 3.3 persons per household* (Number of households = community population / 3.3). Next, instruct each student to use the volume data from his/her "Data Collection" form to estimate the total amount of each hazardous substance present in the households of the community.

Share and compare student estimates for different hazardous substances. Ask students to estimate how much of each of these products and substances will eventually be thrown away, flushed down the sink or toilet into the public water system, or otherwise become hazardous waste. Ask students how reducing the use of hazardous substances would affect the quality of their lives.

Distribute copies of the "Safer Alternatives" sheet and discuss safer substitutes for common hazardous household substances.

## DISCUSSION/QUESTIONS:

A. Ask students to define the terms "hazardous substance" and "hazardous waste."

B. Collect completed Data Collection forms and check for proper classifications of potentially hazardous household products.

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*3.3. persons per household in Cleveland, Ohio (1991)

C. Collect student estimates of the amounts of household hazardous substances present in the households of the community.

## FURTHER STUDY:

A. Divide the class into groups of 3-5 and assign each group a local business such as a grocery store, hardware store, department store, convenience store, or home and garden shop. Ask students to compile a list of potentially hazardous products found in homes and show them to a store manager. Ask him/her to help determine the total amounts (volume or weight) of the listed products sold by the store each year. Arrange interviews at the convenience of the managers.

B. Ask students to estimate the average annual expenditures in the community for products that are classified as being potentially hazardous. Discuss some of the significant factors involved in determining the benefit to the community if consumers primarily used nonhazardous products. Compile all the findings into a report and, after careful review for responsible statements, submit it to local media representatives.

C. Assign students the following home-based assignments:

1. Organize, inventory, and label products containing hazardous substances at home.

2. Inform family members of safer alternative substances for household cleaning, gardening, etc.

3. Investigate the sites in the community or state which hold "amnesty day" for household hazardous wastes: unwanted wastes can be turned in for proper disposal or use by others needing them. The County Recycling office can help you find a collection site in your area.

## ACKNOWLEDGEMENTS:

Our thanks to the Florida Department of Education for its permission to adapt this activity from its *4 Rs Project*.

# PRODUCT LABELS

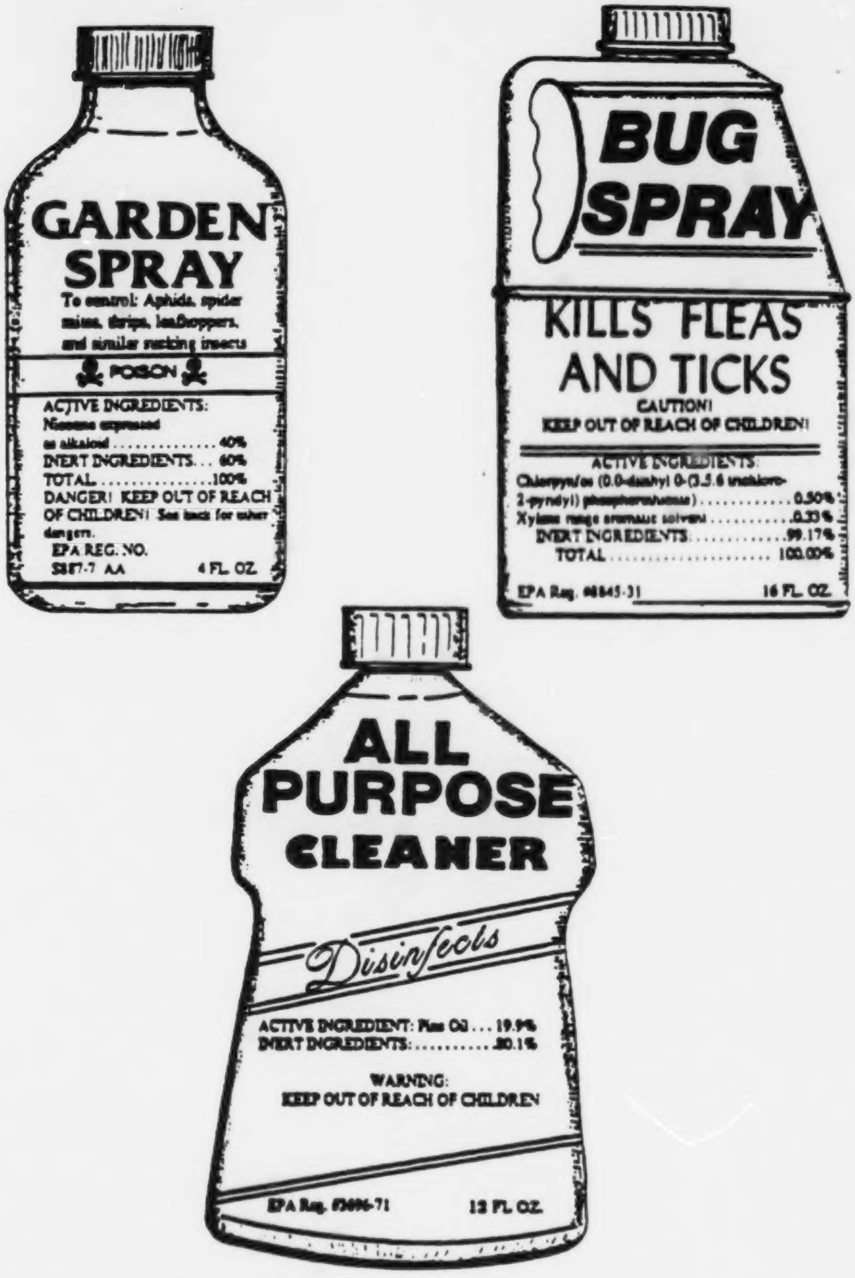
GARDEN
SPRAY
To control: Aphids, spider mites, thrips, leafhoppers, and similar sucking insects
POISON
ACTIVE INGREDIENTS:
Nicotine expressed as alkaloid ..............40%
INERT INGREDIENTS... 60%
TOTAL..............100%
DANGER! KEEP OUT OF REACH OF CHILDREN! See back for other dangers.
EPA REG. NO. 5887-7 AA
4 FL. OZ.
BUG
SPRAY
KILLS FLEAS AND TICKS
CAUTION!
KEEP OUT OF REACH OF CHILDREN!
ACTIVE INGREDIENTS:
Chlorpyrifos (O,O-diethyl O-(3,5,6 trichloro-2-pyridyl) phosphorothioate)............0.50%
Xylene range aromatic solvent...........0.33%
INERT INGREDIENTS............99.17%
TOTAL.....................100.00%
EPA Reg. #8845-31
16 FL. OZ.
ALL
PURPOSE
CLEANER
Disinfects
ACTIVE INGREDIENT: Pine Oil ... 19.9%
INERT INGREDIENTS:...........80.1%
WARNING:
KEEP OUT OF REACH OF CHILDREN
EPA Reg. #3696-71
12 FL. OZ.

Figure from the Florida Department of Education's *4 Rs Project*.

# DATA COLLECTION FORM

| Product Name | Product Use | Hazardous Substance(s) | T[1] | R | I | C | Estimate Product Volume | Hazardous Substance Concentration - % |
|---|---|---|---|---|---|---|---|---|
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[1] T = toxic; R = reactive; I = ignitable; C = corrosive

# KNOW YOUR HOME

| PRODUCT | HAZARDOUS INGREDIENTS | POTENTIAL HEALTH HAZARDS |
|---|---|---|
| Air fresheners & deodorizers | Formaldehyde | Toxic; carcinogenic; irritates eyes, nose, throat, skin; damages nervous, digestive, respiratory systems |
| Bleach | Sodium hypochlorite | Corrosive; irritates & burns skin, eyes; damages respiratory, digestive, nervous systems |
| Disinfectants | Sodium hypochlorite | Corrosive; irritates & burns skin, eyes; damages respiratory, digestive, nervous systems |
| | Phenols | Ignitable; very toxic; damages respiratory & circulatory systems |
| | Trichloroethane | Toxic; vapor irritates skin, eyes, respiratory tract |
| Drain cleaner | Sodium or potassium hydroxide (lye) | Corrosive; burns skin, eyes; toxic; damages nervous, digestive systems |
| | Hydrochloric acid | Corrosive; toxic; damages digestive, urinary systems |
| | Trichloroethane | Toxic; irritates nose, eyes; damages nervous, urinary, digestive systems |
| Flea powder | Carbaryl | Very toxic; irritates skin; damages respiratory, circulatory, nervous systems |
| | Dichlorophene | Toxic; irritates skin; damages nervous, digestive systems |
| | Chlordane & other chlorinated hydrocarbons[1]* | Toxic; irritates eyes, skin; damages respiratory, digestive, urinary systems |
| Floor cleaner wax | Diethylene glycol | Toxic; damages nervous, urinary, digestive systems |
| | Petroleum solvents | Highly ignitable; carcinogenic; irritates eyes, nose, throat, lungs |
| | Ammonia | Toxic; vapor irritates skin, eyes, respiratory tract |
| Furniture polish | Petroleum distillates or mineral spirits | Highly ignitable; toxic; carcinogenic; irritate skin, eyes, nose, throat, lungs |
| Oven cleaner | Sodium or potassium hydroxide (lye) | Corrosive; burns skin, eyes; toxic; damages nervous, digestive systems |

| PRODUCT | HAZARDOUS INGREDIENTS | POTENTIAL HEALTH HAZARDS |
|---|---|---|
| Paint thinner | Chlorinated aliphatic hydrocarbons | Toxic; damages digestive, urinary systems |
| | Esters | Toxic; irritate eyes, nose, throat; damage digestive system |
| | Alcohols | Reactive; ignitable; irritate eyes, nose, throat |
| | Chlorinated aromatic hydrocarbons | Ignitable; toxic; damage digestive, urinary systems |
| | Ketones | Ignitable; toxic; damage respiratory system |
| Paints | Aromatic hydrocarbon thinners | Ignitable; toxic; carcinogenic; irritate skin; damage digestive, urinary systems |
| | Mineral spirits | Highly ignitable; toxic; irritate skin, eyes, nose, throat; damage respiratory system |
| Spot removers | Perchlorethylene or trichloroethane | Toxic; carcinogenic; damages digestive, urinary systems |
| | Ammonium hydroxide | Corrosive; toxic; vapor irritates skin, eyes; damages respiratory system |
| | Sodium hypochlorite | Corrosive; irritates, burns skin, eyes; damages nervous, respiratory, digestive systems |
| Toilet bowl cleaners | Sodium acid sulfate or oxalate or hypochloric acid | Corrosive; toxic; burns skin; damages digestive, respiratory systems |
| | Chlorinated phenols | Ignitable; very toxic; damages respiratory, circulatory systems |
| Window cleaners | Diethylene glycol | Toxic; damages nervous, urinary, digestive systems |
| | Ammonia | Toxic; vapor irritates skin, eyes, respiratory tract |
| Wood stains & varnishes | Mineral spirits, gasoline | Highly ignitable; toxic; carcinogenic; irritates skin, eyes, nose, throat; damages respiratory system |
| | Methyl & ethyl alcohol | Ignitable; toxic; damages nervous system |
| | Benzene | Ignitable; toxic; carcinogenic; damages skeletal, digestive systems |
| | Lead | Toxic; damages digestive, reproductive, urinary, muscular, nervous systems |
| Antifreeze | Ethylene glycol | Very toxic; damages circulatory and urinary systems |
| | Methanol | Toxic; damages nervous, respiratory systems |
| Car wax/polish | Petroleum hydrocarbons, benzene | Ignitable; toxic; carcinogenic; irritates eyes, skin, nose, throat; damages skeletal, digestive, respiratory systems |
| | Lead | Toxic; damages digestive, reproductive, urinary, muscular, nervous systems |

| PRODUCT | HAZARDOUS INGREDIENTS | POTENTIAL HEALTH HAZARDS |
|---|---|---|
| Herbicides (weed killers) | Chlorinated phenoxys (contaminated with dioxin) | Toxic; carcinogenic; irritates skin, eyes, throat |
| Pesticides | Carbamates[2] | Toxic; damages nervous system |
|  | Chlorinated hydrocarbons | Toxic; damages carcinogenic, nervous systems |
|  | Organophosphorus[3] | Toxic; damages nervous system |

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* Items marked with an asterisk [*] are banned or restricted pesticides and should NOT be used by households.

[1] Chlorinated hydrocarbon pesticides are marketed under the following names: Endrin*, Aldrin*, Dieldrin*, Toxaphene*, Lindane, Benzene*, Hexachloride, DDT*, Heptachlor*, Chlordane*, Mirex*, Methoxychlor.

[2] Carbamates are marketed under the following names: Aldocarb*, Ozamyl, Carbofuran, Methyomyl, Sectran, Propoxur, Carbaryl (Sevin).

[3] Organophosphorous pesticides are marketed under the following names: Phorate, Mevinphos*, Demeton*, Disulfotan, Parathion*, Diazinon, Ronnel, Azinphosmethyl.

# SAFER ALTERNATIVES

| PRODUCT | SAFER ALTERNATIVES |
|---|---|
| Air fresheners & deodorizers | Open a window or use an exhaust fan. Sprinkle baking soda in odor-producing areas or set vinegar out in an open dish. Use scented natural potpourri. |
| Bleach | Use a baking soda (sodium carbonate) and water cleaning solution. |
| Disinfectants | Wash items with soap and water or with borax or baking soda in water |
| Drain cleaner | Cover drains with screens to prevent clogging; to loosen clogs, mix 1 cup baking soda, 1 cup salt, 1 cup white vinegar and pour down drain. Wait 15 minutes. Flush drain with boiling water. Use rubber plunger or plumber's snake to remove clogs. |
| Flea powder | Bathe animals with pet shampoos containing insect-repellant herbs, such as rosemary, rue, eucalyptus, and citronella. |
| Floor cleaner/wax | To polish: Mix 1 part thick boiled starch with 1 part soap suds; rub on floor and polish dry with a clean, soft cloth. To clean: Rub with club soda, scrub well, let soak, wipe clean. |
| Furniture polish | Use olive oil, 100% lemon oil, beeswax, or 2 teaspoons of lemon oil and 1 pint mineral oil in a spray bottle. |
| Oven cleaner | Wipe charred spills with a non-metallic bristle brush. Scrub baked-on grease and spills with a baking soda, salt, and water solution. |
| Paint thinner | Use latex paint to eliminate the need for thinner. |
| Paints | Use water-based, non-aerosol paints. |
| Spot removers | Use white vinegar or a solution of equal parts of ammonia and water. |
| Toilet bowl cleaner | Use 3 teaspoonsful ammonia, 1 teaspoon white vinegar, and 3/4 cup of water in a clean spray bottle; or use a solution of 2 tablespoons of vinegar in 1 quart water. |
| Pesticides | Garden: Spray plants with a solution of 3 tablespoons soap per gallon of water. Spray with pyrethrum (a chrysanthemum-based natural pesticide).<br>Household insect spray: Grind 1 clove garlic and 1 onion. Add 1 tablespoon cayenne pepper and 1 quart water. Mix well. Let steep 1 hour and add 1 tablespoon liquid soap. |

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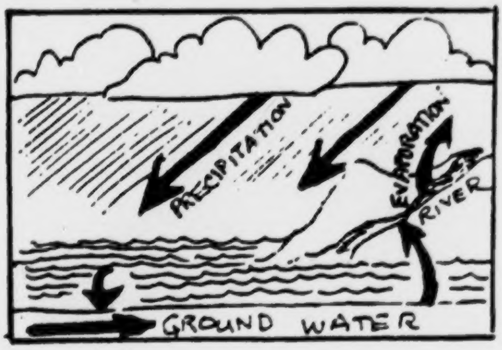
# WHAT GOES AROUND COMES AROUND

**Subjects:** Science, environmental science, physical science, chemistry, biology, language arts, social studies, home economics, industrial arts

**Format:** Teacher demonstration, class discussion, optional home writing assignment; one class period



**OBJECTIVE:** Students will learn (1) that materials disposed of can return to us through both physical systems, such as groundwater cycling, and bioaccumulation; (2) safe disposal options for non-hazardous and hazardous materials; (3) where materials go that are poured down a storm drain, ditch, or hole in the ground; poured down a sink or flushed down a toilet; put in a garbage can for pick-up; or incinerated; and (4) the concept that "environment" is an integrated system in which everything is connected to everything else.

**METHOD:** Students will be given information on how groundwater and soil contamination and bioaccumulation occur; the teacher will present both overheads and handouts. As a recommended home assignment, students will be asked to write a brief essay describing the processes discussed to confirm their understanding of them.

**BACKGROUND:** Hazardous substances can enter our environment in a wide variety of ways. Because the subject involves an introduction to environmental systems by way of human choices about how to dispose of items, this activity is primarily based in information sharing, discussion, and analysis. Key vocabulary and concepts for this activity are the following: household hazardous waste, ground water quality, bioaccumulation, ecology, persistent chemicals, impermeable, aquifers, microlayers, sewage treatment, sludge, leachate. All of these are treated in the student handouts, "Incineration," "Storm Drain, Ditch, & Hole in the Ground," "Sink & Toilet," "Garbage Can," and "Household Hazardous Waste Collection." Along with the "Bioaccumulation" and "Routes to the Environment" illustrations, they provide an overview of the principle that environmental cycles are life-sustaining. They are also life-threatening when poor human choices about waste disposal are made.

## MATERIALS: For this activity you will need the following items:

- Examples (containers) of commonly used household products, such as motor oil, pesticides, paint thinner; as a substitute, you can use the "Product Labels" handout in the activity, "Hazards in Your House"; also useful would be the list of chemicals and their safer alternatives in the same activity, i.e., "Know Your Home" and "Safer Alternatives"
- Protective gloves (optional), if you bring in actual materials
- Overhead transparencies titled "Routes to the Environment" and "Bioaccumulation" (these items follow this activity)
- Student handouts on disposal options: "Incineration," "Storm Drain, Ditch, & Hole in the Ground," "Sink & Toilet," "Garbage Can," and "Household Hazardous Waste Collection" (these items follow this activity)
- "Where Will It End Up" worksheet (follows this activity)

## PRE-ACTIVITY QUESTIONS:

A. What are "persistent" hazardous substances? (Those that do not degrade readily, remaining intact through the foodchain or aquifer, such as lead, mercury, cadmium.)

B. Why are persistent hazardous substances of particular concern in waste management?

C. What is bioaccumulation? (Term used to describe those chemicals that remain and concentrate in the food chain from simpler animals to the more complex through the prey/predator cycle. See the five steps illustrated on the "Bioaccumulation" handout)

# PROCEDURE:

A. Bring to class one or two examples of some common types of household or school hazardous substances. Motor oil, pesticides, and paint thinner are good examples of products that are known to be persistent and long lasting in the environment. Handle these products with care. As a precaution, notify the school and/or parent if you intend to bring these products to class. You may wish to bring empty containers. If you prefer, make copies of the "Product Labels" handout in the activity, "Hazards in Your House." If you bring actual materials, restrict student handling of these products. Wearing gloves for protection will emphasize the hazardous nature of these products.

B. Explain that some combinations of hazardous chemicals degrade (break down) quickly into safe, naturally occurring substances. Explain that in this activity we are primarily concerned with persistent hazardous chemical combinations - those that remain unchanged in the environment for long periods, or chemicals, that combine with natural substances in such a way as to pose a hazard to humans and other living organisms. Show the overhead "Bioaccumulation" and discuss the concept with students. Then ask and discuss the following:

What should we do with these products when we are through with them?

What are the different ways we might dispose of them? (Recycle, flush down the drain, put in the garbage can, burn in the back yard, pour out on the ground or pavement.)

Tell students that some disposal options are no longer legally available, but for the purposes of this activity, we will want to think about what happens to substances when they are disposed of in various ways.

Discuss with students any directions for disposal that the labels on the products give. For example, most motor oil containers suggest recycling.

C. Next, review with students that part of the study of ecology is the examination and understanding of connections. To learn about some of the connections, the class will now consider how each of the possible ways we might use to dispose of household hazardous waste could be connected to our food and water supplies.

Tell students they are now going to consider where wastes go. Show the overhead "Routes To The Environment." Point out to the class the various ways a chemical can travel through the environment from our homes.

D. Divide the students into groups or pairs and assign a different disposal method to each group.

- Incineration
- Storm drain, ditch, hole in the ground
- Sink/toilet
- Garbage can
- Household hazardous waste community collection

Assign each group to brainstorm for several minutes on where substances disposed of by their designated disposal method might end up. You may wish to assign a different hazardous product to each group. Questions that each group can ask themselves are:

1. If we dispose of the product by this method, what might happen?
2. What ways, if any, might wildlife be harmed?
3. How could chemicals in this product get into our drinking water?
4. How could chemicals in this product get into our food?

Ask the groups to use the "Where Will It End Up" chart to write down their ideas.

E. Ask groups to share their ideas with the rest of the class. After each group presents its ideas, discuss with the class the information contained in disposal option sheets that are included with this activity. Pass these out to the class. (You may wish to assign a home essay describing the various cycling of materials and entry routes back to us and other living things through water and food.) Ask the class to vote on the best disposal choice for each product. Discuss the pros and cons of these choices.

F. After all the options have been covered, review with the class where persistent household hazardous waste goes.

Ask students what can be done to reduce the amount of household hazardous waste we produce -- i.e., to eliminate or reduce the waste before it becomes a problem for us and the environment.

Ask students to brainstorm ways that we can prevent persistent hazardous substances from harming the environment. Ask them to suggest solutions that they themselves might do, such as:

- Buy products that don't contain hazardous materials. Learn to read product labels. (See "Know Your Home" and "Safer Alternatives" handouts in the activity "Hazards in Your House" for lists of chemicals and side effects and alternatives to conventional hazardous products.)

- Use up what you have or, if it is not a banned chemical, find someone who can use it.

- Take it to a hazardous household waste collection program or a recycling center that handles hazardous substances.

Tell students that they can get information about participating in a collection program by calling the County Recycling office.

**SOURCES:** Much of the information in this activity is taken from the activity guide *Sleuth, Educational Activities on the Disposal of Hazardous Waste*, published by METRO, The Municipality of Metropolitan Seattle. For information on this activity guide please contact Dave Galvin, METRO, 821 2nd Avenue, Seattle, WA 98104 206/684-1233.

## RESOURCES:

Brochure "Protecting our Ground Water." U.S. Environmental Protection Agency, 1985.

*Household Hazardous Waste Wheel.* Environmental Hazards Management Institute, 1987.

Video Tape *A Little Goes A Long Way.* Washington State Department of Ecology, 1987. 18 mins.

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## ACKNOWLEDGEMENTS:

We are grateful to the Washington State Department of Ecology for permission to use and adapt this activity from *A-Way with Waste*.

# INCINERATION

If you burn your household hazardous wastes, what happens? This depends on the type of chemical in the waste being burned. A pressurized aerosol can could explode and cause injury. Burning paints could leave a residue of heavy metals which is toxic. Burning rags soaked with cleaning fluid might simply vaporize the liquid into the air. This would disperse it and thus make its concentration very low.

Burning plastic containers or certain solvents could release potentially harmful fumes like hydrogen cyanide or chlorine-bearing compounds that are harmful if inhaled. Some of the chlorine-bearing compounds do not break down easily and last a long time. Over time, these compounds can accumulate to levels that are harmful to the atmosphere.

Check with your local Environmental Protection Agency office regarding the legality of incinerating materials in your community.

In addition, the burning of household hazardous substances by individuals is never complete. This means that waste is illegal if small particles from paper or cloth are released into the air. These particles, which can carry toxic substances, may settle and form a very thin layer called a microlayer on different surfaces, such as plant leaves. The toxic substances in the layers can interfere with vital biological processes. Microlayers can also form on the surface of water. Because microlayers form at the place called an interface (where two different states of matter meet such as liquid and gas or solid and liquid) it is much more likely that toxic substances will become concentrated in these microlayers.

Finally, human beings can breathe small particles into their lungs and absorb the toxic substances into their bloodstream. (Our lungs are an interface with the atmosphere.)

# STORM DRAIN, DITCH, & HOLE IN THE GROUND

If you pour household hazardous waste in a storm drain, in a ditch, or in a hole in your backyard, there's a good chance the waste will end up in a nearby stream, river, or lake. Let's figure out exactly where your waste might go.

It might go down the "storm drain (or "catch basin")," the square metal grates at the sides or curbs of streets. When it begins to rain, the first drops soak into the ground, but once the soil is saturated or if it's covered by cement, the rain runs into these storm drains. They drain anything soluble, such as salt on your driveway, sidewalks, or street, into the storm sewer system, washing along other solid materials, such as animals feces.

Once there, this "runoff" water enters pipes which carry it to larger underground pipes or "trunk lines." They empty the water into the nearest drywell or waterway (creek, lake, river). So if you pour used motor oil down the storm drain along your street, it well may end up on the feathers of ducks or in the gills of fish in a nearby lake.

In some areas, the storm drain joins sanitary sewer pipes and the runoff water goes to a sewage treatment plant as a "combined sewer system." In this case, water containing your hazardous waste will be treated. Some sewage plants have only a single treatment stage which will not eliminate most hazardous wastes; others have secondary treatment plants that eliminate many more, but not all, hazardous wastes. However, these are very expensive. What kind of systems do you have in your city?

Next to consider is the ditch or your backyard, because in some areas there are no storm drains. Once the soil is saturated, rainwater runs overland to the nearest ditch or gully and downhill to the nearest waterway. If you disposed of a household hazardous waste, e.g., a pesticide, in your backyard or applied it to your lawn, and it rained hard the next day, the rain would carry the substance over land along the ditches to a waterway or down into the ground water.

"Ground water," "water table," "aquifer," "artesian well," and "springs" are names which describe where water is and how it moves underground. Water drains or soaks into the ground until it hits an impermeable (difficult to penetrate) layer. The water then collects in the spaces between sand, gravel, or rock particles. Underground areas where ground water collects are called aquifers. Some aquifers replenish lakes or streams. Others are enclosed by layers of rock and do not move. Wells are drilled into both kinds of aquifers, those that flow and those like pockets. Aquifers around the country are becoming contaminated at an alarming rate, threatening drinking water supplies.

Of all the water available, only a small amount is actually available for drinking purposes. From where does your drinking water come?

## SINK & TOILET

When you pour the substance down the sink or flush it down the toilet where does it go? It goes either to the municipal sewage treatment system or into a septic system.

The sewage system is a network of underground pipes that collects liquid waste from each house, store, office, factory, and building and brings it together into huge pipes called trunk lines. These trunk lines carry enormous volumes of waste.

Not long ago, sewage used to be dumped directly into rivers, lakes, sounds and oceans. What problems did this create?

Now, most cities and towns have municipal sewage treatment plants to remove sewage before the transporting water is pumped into nearby lakes or rivers.

At the sewage treatment plant, the water is treated with chlorine to kill any disease-causing organisms in the raw sewage. Much of the solid material and some of the heavy metals are also removed by allowing them to settle out of solution. Common heavy metals are lead, zinc, mercury, and cadmium. Exposure to heavy metals, in any amount other than small concentrations, can be harmful to human and environmental health.

Some of the toxics in the sewage biodegrade, while others, including some of the heavy metals, settle out in a residue called sludge. Sludge is often disposed of in a landfill but is sometimes applied as a fertilizer to forest land. Some hazardous chemicals can be absorbed by plants, and these plants, in turn, are eaten by animals in which the chemicals can accumulate and concentrate to dangerous levels. This process is called **bioaccumulation**. The Environmental Protection Agency has set standards for the level of toxicants in sludge that may be used on farm or garden soils producing food. As a substance moves from one organism to another, through being eaten or by absorption, the substance is said to move through a food chain. Each link in the chain may accumulate the hazardous substance in higher concentrations. Human beings are often at the top of a food chain, which means the food we eat has had a chance to bioaccumulate many times.

If your house is not connected to a sewer system, it is probably connected to a septic tank. Many gallons of water and sewage go through these septic systems each day. (For example most toilets use five to seven gallons for every flush.)

Bacteria break down much of the waste entering a septic system. However, if you pour or flush hazardous waste into a septic system, the waste can kill this helpful bacteria and can contaminate the septic tank sludge or septic system's drain field soil. This sludge, pumped every four or five years from the septic tank, is disposed of either at a sewage treatment plant in a septic lagoon or in sludge landfill (basically a hole in the ground). The septic system can last indefinitely if the sludge tank is pumped out periodically. If the system is not pumped regularly, the bacterial action may stop, allowing harmful substances into the ground water; or, the drain field may get blocked causing the system to back up.

The suspected cancer-causing chemical trichloroethylene (a powerful solvent and degreaser) has leached from septic tank drain fields in several places in the country to contaminate local wells. This compound, used in the past as a cleaner for septic tanks, is the suspected source.[1] Chlorinated compounds make good cleaning agents, but they are persistent, toxic, and mobile. Bacteria that can break down nonchlorinated substances cannot biodegrade these compounds, which pass through such systems into the drain field and ultimately may end up in drinking water sources.

Today, we are only starting to recognize and to understand the environmental damage caused by household waste. There is no doubt that treatment removes or makes less harmful some of the toxic substances found in sewage. Some hazards, however, are not removed and are pumped into rivers and lakes and thereby enter the food chain, to which we may be the final link.

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[1] According to the Seattle, Washington Water Quality Division's "Metro Toxicant Report No. 1E"

# GARBAGE CAN

Until recently, once you had put your trash in the garbage can, you probably didn't think about it any more. The garbage truck came by every week and took it away. But lately, garbage has been in the news. Remember the garbage barge?

What happens to your garbage after it's picked up? Where does it go?

In some areas, the garbage truck takes your trash to a transfer station. From there, it is hauled by large trucks to a landfill.

What happens to garbage after it reaches the landfill? What happens to hazardous waste if you put it in the garbage?

Trash in landfills used to be burned to reduce the volume. This produced a relatively nontoxic ash, but incineration sent hazardous emissions into the air. Consequently, open burning was stopped and replaced by compaction and burial of waste. The waste at a landfill is heavily compacted. As a result, almost any container will break and the contents spill. Those contents sometimes leach through the landfill into the ground.

In addition, rainwater soaks through the garbage. Soluble (dissolvable in water) hazardous materials may be washed down with them. This liquid mixture is called leachate. Leachate will go down through the soil until it reaches an impermeable layer (a layer it cannot go through), or it will flow downhill over the surface. Leachate can contaminate ground water and surface waters. Landfills constructed today must have a protective lining, a leachate collection system, and a ground water monitoring system. However, many of our existing landfills were established prior to these requirements, and they all leak.

So if you throw household hazardous waste in the garbage can, the waste's persistent components may end up in the soil, ground or surface water near your local landfill, and again enter the food chain.

# HOUSEHOLD HAZARDOUS WASTE COLLECTION

Many communities now sponsor household hazardous waste collection programs. Most rural and urban populations rely almost exclusively on ground water for water needs and are particularly concerned about safely collecting household hazardous wastes in order to keep them out of local landfills and out of drinking water.

During a collection program, people can bring in household hazardous materials, usually at no cost. In cooperation with private hazardous waste management companies, county workers record and pack hazardous waste in drums for shipment.

Some of the material can eventually be rendered safe by hazardous waste management companies using various chemical, physical, and/or biological techniques. Some can be recycled (e.g., motor oil and solvent). Others must be shipped, at a high cost, to a hazardous waste landfill or high temperature incinerator.

If you participate in a local program and take your household hazardous waste to a collection site, your waste will be safely handled. It will be transported for treatment, long-term storage, or disposal in an approved hazardous waste landfill or incinerator.

# WHERE WILL IT END UP?
# HOUSEHOLD HAZARDOUS WASTE DISPOSAL EFFECTS

Without proper disposal, many hazardous wastes make their way back to us through the natural cycles of the environment. Using the chart below, check off the areas affected by each disposal method under each product. Compare your findings with those of other students. Discuss your reasoning on differences in your answers:

| PRODUCT | | Affected Environmental Element<br>AIR | WATER | WILDLIFE | SOIL | HUMANS | OTHER |
|---|---|---|---|---|---|---|---|
| 1. Paint thinner | | | | | | | |
| Disposal Choice* | I | | | | | | |
| | SD/D/H | | | | | | |
| | S/T | | | | | | |
| | GC | | | | | | |
| | HHWCC | | | | | | |

| PRODUCT | | Affected Environmental Element<br>AIR | WATER | WILDLIFE | SOIL | HUMANS | OTHER |
|---|---|---|---|---|---|---|---|
| 2. Motor oil | | | | | | | |
| Disposal Choice* | I | | | | | | |
| | SD/D/H | | | | | | |
| | S/T | | | | | | |
| | GC | | | | | | |
| | HHWCC | | | | | | |

| PRODUCT | | Affected Environmental Element<br>AIR | WATER | WILDLIFE | SOIL | HUMANS | OTHER |
|---|---|---|---|---|---|---|---|
| 3. Weed killers | | | | | | | |
| Disposal Choice* | I | | | | | | |
| | SD/D/H | | | | | | |
| | S/T | | | | | | |
| | GC | | | | | | |
| | HHWCC | | | | | | |

* Disposal choice abbreviations are I = Incinerate; SD/D/H = Storm drain/Ditch/Hole in the Ground; S/T = Sink/toilet; GC = Garbage can; HHWCC = Household Hazardous Waste Community Collection

# WHERE WILL IT END UP?
# HOUSEHOLD HAZARDOUS WASTE DISPOSAL EFFECTS (cont.)

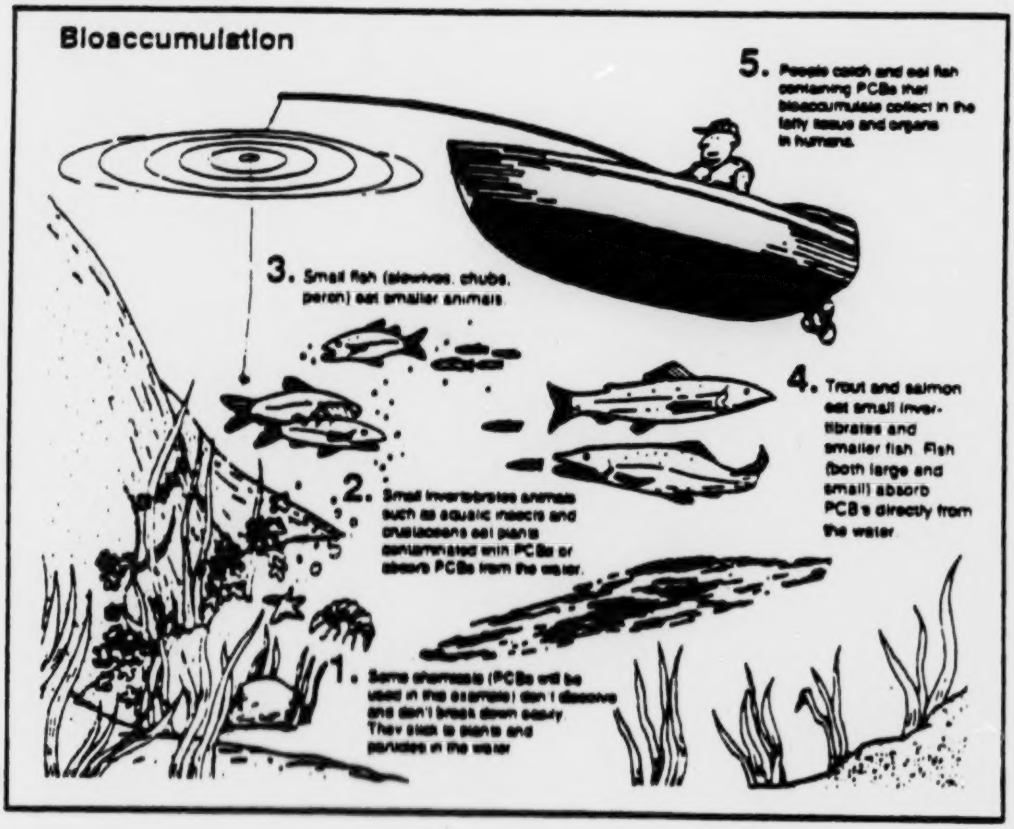
| PRODUCT | | Affected Environmental Element<br>AIR | WATER | WILDLIFE | SOIL | HUMANS | OTHER |
|---|---|---|---|---|---|---|---|
| 4. Aerosols | | | | | | | |
| Disposal Choice* | I | | | | | | |
| | SD/D/H | | | | | | |
| | S/T | | | | | | |
| | GC | | | | | | |
| | HHWCC | | | | | | |

| PRODUCT | | Affected Environmental Element<br>AIR | WATER | WILDLIFE | SOIL | HUMANS | OTHER |
|---|---|---|---|---|---|---|---|
| 5. Other: ________ | | | | | | | |
| Disposal Choice* | I | | | | | | |
| | SD/D/H | | | | | | |
| | S/T | | | | | | |
| | GC | | | | | | |
| | HHWCC | | | | | | |

| PRODUCT | | Affected Environmental Element<br>AIR | WATER | WILDLIFE | SOIL | HUMANS | OTHER |
|---|---|---|---|---|---|---|---|
| 6. Other: ________ | | | | | | | |
| Disposal Choice* | I | | | | | | |
| | SD/D/H | | | | | | |
| | S/T | | | | | | |
| | GC | | | | | | |
| | HHWCC | | | | | | |

* Disposal choice abbreviations are I = Incinerate; SD/D/H = Storm drain/Ditch/Hole in the Ground; S/T = Sink/toilet; GC = Garbage can; HHWCC = Household Hazardous Waste Community Collection

# BIOACCUMULATION



Bioaccumulation

5. People catch and eat fish containing PCBs that bioaccumulate collect in the fatty tissue and organs in humans.

3. Small fish (alewives, chubs, perch) eat smaller animals.

4. Trout and salmon eat small invertebrates and smaller fish. Fish (both large and small) absorb PCB's directly from the water.

2. Small invertebrates animals such as aquatic insects and crustaceans eat plants contaminated with PCBs or absorb PCBs from the water.

1. Some chemicals (PCBs will be used in this example) don't dissolve and don't break down easily. They stick to plants and particles in the water.

Figure from Washington State Department of Ecology's *A-Way with Waste.*

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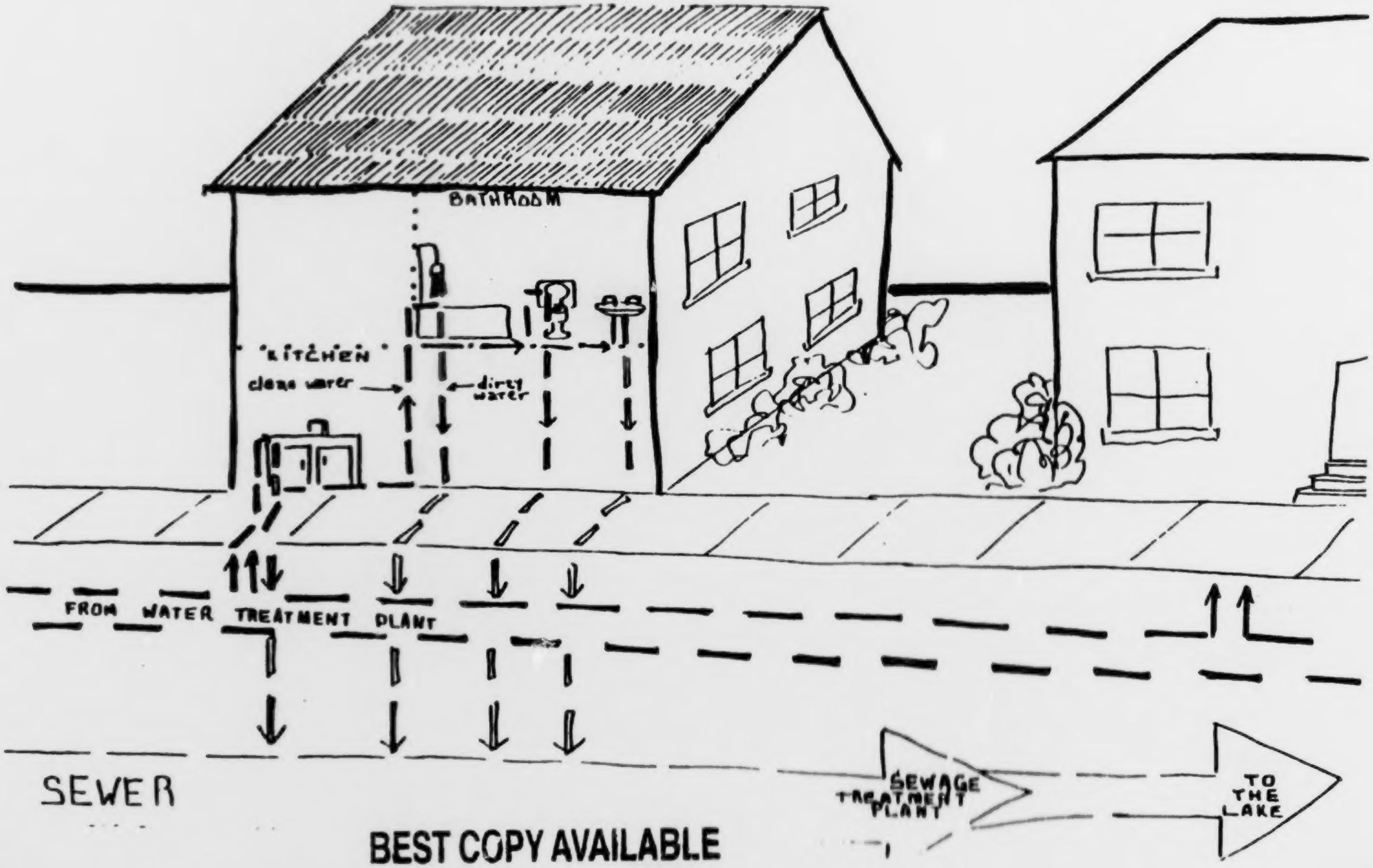
# ROUTES TO THE ENVIRONMENT

## URBAN HOUSEHOLD WATER SYSTEM


BATHROOM
"KITCHEN"
clean water
dirty water
FROM WATER TREATMENT PLANT
SEWER
SEWAGE TREATMENT PLANT
TO THE LAKE

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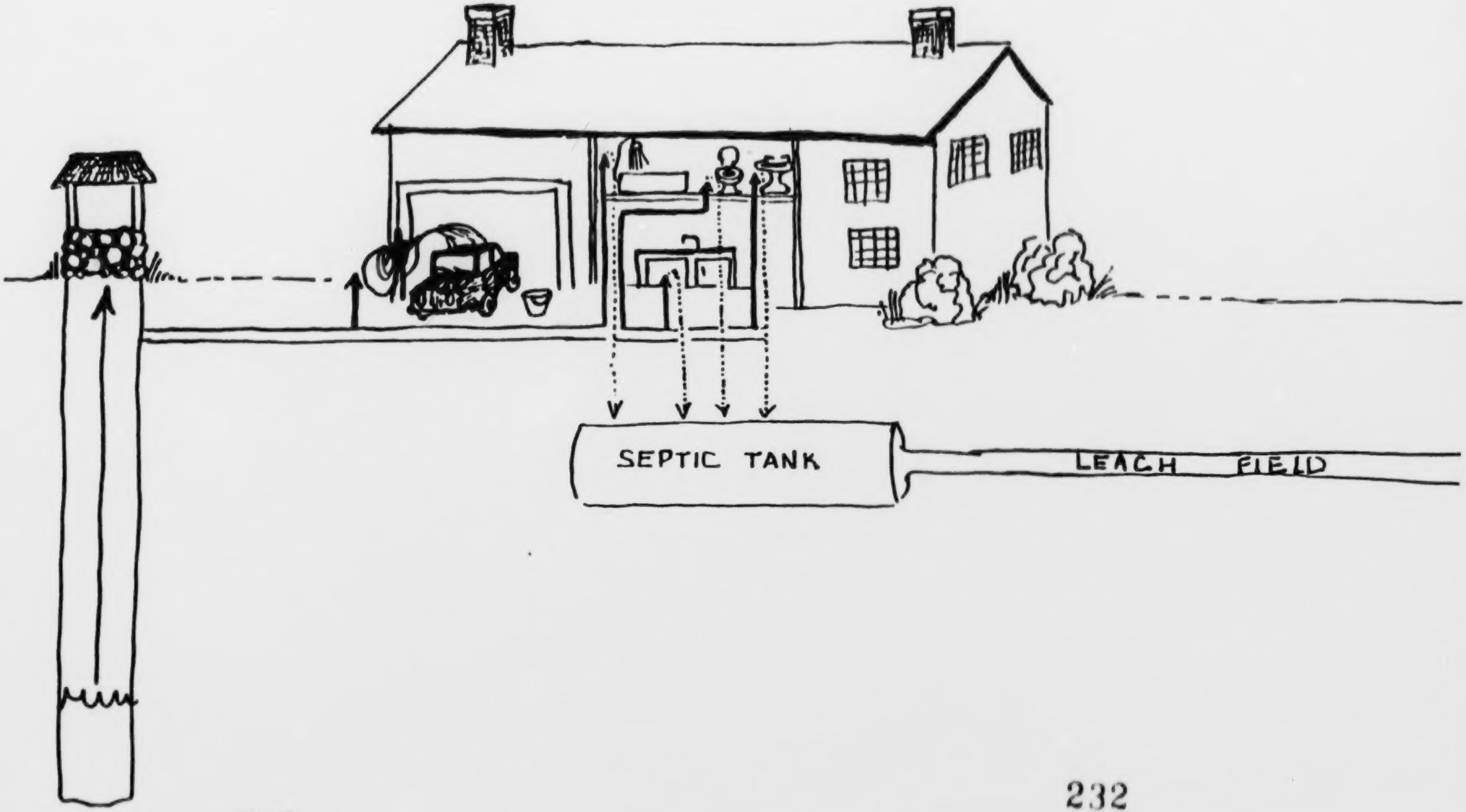
## RURAL HOUSEHOLD WATER SYSTEM

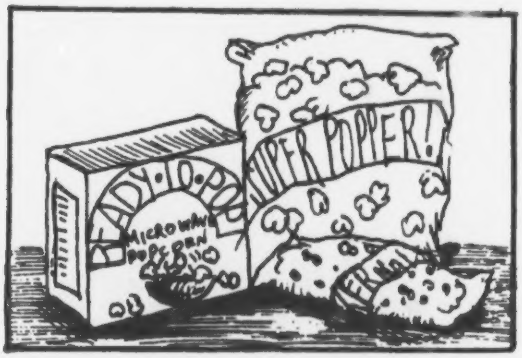

SEPTIC TANK
LEACH FIELD

232

# LET'S HAVE SOME POPCORN . . . BUT *WHICH* POPCORN?

**Subjects:** Consumer literacy, language arts, life skills, mathematics

**Format:** One to several class periods, depending on the teacher's election of options in the activity



**OBJECTIVE:** Students will learn (1) how the solid waste problem increases with some purchases they make; (2) that some purchases leave more solid waste than others; (3) that many of those that leave more waste also cost more; (4) the most economical way to buy popcorn; (5) where to look for ingredients to learn what's in the popcorn besides corn; (6) how to work together as part of a team in solving a problem; and, if the teacher wishes to demonstrate it, (7) how to prepare popcorn from scratch.

**METHOD:** The teacher provide prepopped popcorn, microwave popcorn, and ingredients for popcorn from scratch. The teacher will either prepare the microwave and popcorn-from-scratch in advance or, preferably, have the students make it in class. Children will then measure how many cups are in each kind. The teacher will also provide all of the containers coming with each type of popcorn so that students can examine the waste and recyclables generated and the ingredients in each kind of popcorn.

**BACKGROUND:** Children grow up to be the consumers. There are many influences on what they buy -- family buying practices (e.g., buying fast foods, processed foods, frozen foods, etc.), socio-economic factors, convenience, education, beliefs. If children are to become environmentally wise food shoppers, there are many factors they should consider when they shop: (1) what are the ingredients of the food? Are they healthful? (2) what kind of packaging does the food have? Is it necessary? Recyclable?

Reusable? (3) that there are differences in the overall cost of foods -- and those costs include such considerations as the amount of food packaging; whether the packaging is waste, reusable, or recyclable, and the comparative cost of disposing of waste versus reusing or recycling it; and what the nutrition levels of the food are (e.g., fresh and natural ingredients versus artificial ingredients, including preservatives).

The main goal of this activity is to have students discover the relationship between packaging and convenience foods. At an early age children need to understand that when they buy something, they also buy the packaging. They have a responsibility as a good citizen to see that the packaging is minimal and that it is reused or recycled, if possible. If it is waste, they need to know where to dispose of it properly.

Popcorn is a simple and familiar subject to use as the subject of an awareness lesson on solid waste -- where solid waste comes from, what it costs, what can be done to avoid it. If the teacher has the children handle the popcorn wearing plastic gloves or baggies to keep it sanitary, the students can have the popcorn as a treat later.

If the teacher is not going to serve the popcorn to the students, some provision should be made for feeding it to wild birds. (Since it is not air popped and has been buttered, it probably would not be suitable as a packing material unless sealed off in plastic baggies. The quantity of butter is probably small enough that the popcorn could be composted -- i.e., amount of dairy product is minute -- if someone has a large enough compost area to accommodate the volume.)

**MATERIALS:** The set of materials in List A is for teachers who will have students make the microwave popcorn and popcorn-from-scratch in class. (Some teacher's lounges may have the necessary microwave or hot plate available for class use.) List B is for teachers who prepare the microwave popcorn and popcorn-from-scratch at home, bringing in the prepared popcorn -- and all of its packaging -- for the children to measure and observe, respectively. **NOTE:** Sizes, amounts, and brands are specified because they are familiar and can serve as a basis for cost changes later if a follow-up study were to be done.

**A. List for in-class cooking**

(NOTE: If teachers choose to have students make popcorn in the classroom, they should clear it with the principal and alert colleagues nearby whose students will surely detect the aroma! Assure them that a lesson is underway.)

1. Snyder of Berlin: Superpop Pack Butter Flavored Popcorn, three 8.5 ounce bags

2. Box of microwave popcorn (6-pack): Betty Crocker Pop-Secret Light Microwave Popcorn, six 3-ounce packages

3. Ingredients for popcorn from scratch:

   Seaway Popcorn, 16 ounce bag (pop all of it)

   Mazzola Corn Oil, 16 ounces

   Hillandale Farms Butter, 1 pound in measure-marked sticks

   Salt, a 3-cup package (i.e., weighs 1 pound 10 oz.)

4. 3 quart pan with lid for preparing popcorn from scratch

5. Knife to cut butter

6. Measuring cup for popcorn

7. Hot plate

8. Pot holders

9. Microwave oven

10. Large plastic bags for transferring popcorn while measuring (3 quart or greater capacity)

11. Plastic gloves (or substitute reusable plastic baggies) for students who are measuring popcorn

12. Three 8-ounce cups or three 2-cup measuring cups

13. (Optional) Brown bags for students' popcorn -- whether eating in class or taking home (these can usually be recycled with corrugated cardboard; oil/butter staining should be negligible contamination -- but ask your local recycler for guidelines)

14. Student handouts:

    a. "How Much Popcorn Is There?"

    b. "What's in My Popcorn Besides Corn?"

    c. "Popcorn Packages -- What Are They Made of & Where Do They Go Next?"

    d. "Popcorn -- How Much Does It Cost?"

    e. "In Pictures" versions of each of the above handouts, "a" through "d." (If children have not had multiplication, division, fractions, and estimating, you can use the alternative handouts with "In Pictures" preceding the titles. These show the amount of popcorn, how much it costs, how much waste is produced, etc.)

15. 3 cards with the cost of a cup of popcorn -- 3 cents, 6 cents, and 7 cents -- written in large, bold letters so that children can see it readily. (These will be propped up in front of each popcorn type when you are ready to ask the students to estimate what they think 1 cup of each kind of popcorn costs.)

16. A "Teacher's Data Sheet" shows the calculations for arriving at the cost of popcorn and the amount of waste and recyclables associated with each of the three kinds. A "Teacher Notes: What's in My Popcorn besides Corn?" reference sheet describes the various ingredients found in the popcorn. "A Teacher's Answer Sheet" provides answers to the student handout, "Popcorn Packages -- What Are They Made of & Where Do They Go Next?"

**B. List for teachers who prepare the popcorn at home:**

All of the above items, except for these changes:

In pre-cooking the microwave popcorn and the popcorn from scratch at home, be sure to bring in the boxes, wraps, empty containers, partially full containers. Microwave all 6 bags of microwave and pop all 16 ounces of the popcorn from scratch. The activity calls for students to be able to examine all of the ingredients and packaging.

**PRE-ACTIVITY QUESTIONS:** Ask students the following questions (You will have to adjust questions somewhat if you plan to cook the popcorn in class):

A. Do you ever have popcorn to eat as a snack at home? How does your family buy it? (Already popped? Microwave popcorn? Popcorn from scratch? Ask for a show of hands and assign a student to put the numbers for each on the blackboard.)

B. Hold up all of the containers -- one of the three bags of pre-popped popcorn, the box of microwave popcorn, and the popcorn from scratch:

If we cook all the microwave popcorn and the unpopped popcorn, will we have more popcorn or less popcorn than is in this bag of already popped corn? (Have the children put up their hands: count the tally and ask the student to put on the board how many said "More" and "Less.")

C. For those who make popcorn from scratch, do you need to buy anything else besides this unpopped popcorn to make popcorn at home? (List the student's comments on the blackboard or, if the students are writing and spelling regularly in class, ask one of them to record answers.)

D. Point to all three containers. Tell the students that you want them to do some math work: To figure out the cost of one cup (hold up a cup) of each kind of the three kinds of popcorn. Ask them the following and have a student record their answers on the board:

How many of you think that a cup of each one costs the same?

If they don't cost the same, which one do you think costs the most?

Which one costs the least? Which one is in between?

E. Which popcorn has the most packaging? (Remind them that popcorn from scratch requires **other** ingredients, so that packaging should be listed, too.) Ask the students to name what the packaging is (box, cellophane bag, plastic bag, paper for butter sticks, etc.).

F. What should be done with the packaging? Is it thrown away? Recycled? Can it be reused for something else? (Use the list they generated in "E," above. Have students record the answers.)

NOTE: If your class has not discussed "recycling" and "reuse" before, you will have to introduce students to the terms. First, ask if any students know where items go that are "thrown away." (To the landfill or to an incinerator.)

What happens to recycled items? (They eventually go to a recycling facility: glass is made into recycled glass, paper into recycled paper, etc.)

What does "reuse" mean? What are some examples? (Possible answers include using plastic margarine containers for cat food, handing down clothes from an older to a younger sister or brother, etc.)

G. Can we recycle any of the packages that the popcorn comes in? Any of the packages of the other items (name the ones the students have named in "C," above) for making popcorn-from-scratch?

H. What are "Ingredients"? "Preservatives"? "Artificial ingredients" Where have they heard these words before? What do they know about them? (Ask where they learned their views: parents, TV -- if, so, from what product, TV/movie/sports/music star, etc.)

# PROCEDURE:

**A.** **POPPING CORN IN CLASS:** If students are preparing the popcorn in class, tell them that you will need volunteers to cook it. Cook one kind at a time, instructing students on the amount of time to enter on the microwave; how much oil and butter to use for popcorn-from scratch, etc. This is an excellent opportunity to introduce students to practical life skills of cooking and measuring and to encourage boys as well as girls to prepare food.

Tell the students that when you finish making the popcorn, you will also need their help in measuring it and then packaging it for them to take home.

**B.** **MEASURING:**

1. Tell students that they will now help measure the three kinds of popcorn. NOTE: if you prepare the popcorn in advance, take care that it doesn't get crushed in transit, since this will lessen the number of cups each one yields.

2. Divide the class into three teams: prepopped, microwave, and popcorn-from-scratch. Tell them that they are to figure out which makes the most

popcorn. Put the 3 bags of the 8.5 ounce prepopped popcorn, the 6 bags of microwaved popcorn, and the container of the popcorn-from- scratch on tables so the students can easily reach them.

a. Each team has a **scooper** (who wears plastic gloves), a **cup holder**, a **recorder**, a **bag holder**, a **marker**, and as many **counters** as there are students remaining.

b. Instruct the scoopers to be very, very gentle when lifting out the popcorn and putting it into the cup-holder's cup. The goal is to measure accurately.

c. The cup-holder should empty each cup into the bag-holder's bag, while the marker should draw a circle around a cup (on their "How Much Popcorn Is There?" sheet) each time a cup is poured into the bag.

d. When all the popcorn has been measured and marked on the sheet, the counters then count the number of cups circled and write out the total on the sheet for each kind of popcorn.

3. Finally, have the students bag the popcorn to take home.

C. **LOOKING AT INGREDIENTS:** Keep the students assigned to their respective teams and tell them that they are now going to circle on their "What's In My Popcorn Sheet" all of the ingredients that they find listed on the packages of the popcorn and the ingredients used to make popcorn from scratch. Ask each team to circle at the top of the page the kind of popcorn they are investigating.

1. Ask students where they would look to find the ingredients listed on the package.

2. On tables set out the bag from the prepopped popcorn; the box from the microwave popcorn; and the bag from the popcorn-from-scratch and the containers for the oil, butter, and salt.

3. Ask the students the following and have a student record the answers on the board under the name of the three types of popcorn:

   Which of the three had letter "a" (popcorn), "b" (salt), and so on down the list.

4. Ask them: What is salt? What is TBHQ? How could we find out what TBHQ is?

   (Betty Crocker has a toll-free consumer information line for questions such as these: 1/800/231-0308.) Why does the company put it in the food it makes? Is there a name and address on the package that tells us where to write to find out information? Shall we write to the company to ask about TBHQ? (The students might wish to do this: write a letter which says, among other things that they choose to highlight, that the class is learning how to look for and understand the list of ingredients on the packages of food they eat. They would like to learn what "x" ingredients are so that they can learn more about how to choose healthful foods. How does "x" help to make food healthful? Are there things about "x" that may not be healthful? The students might also ask the company to please write in language that kindergartners through 4th graders (or whatever the grade level is) could understand, since they are interested in learning as much as possible about what it is they are eating. The entire class might wish to sign the letter. It would probably be helpful to address the letter to "Attn: Customer Service" or "Consumer Information.")

D. **LOOKING AT PACKAGING:** Keeping the assigned teams of students, have them examine the packaging for the products. Ask them:

1. What would you do with the bag (bottle, box, wrapper, etc.) when it is empty?

2. How do you know what to do with it?

3. Where does it go once you throw it away, recycle it, burn it, etc?

   Depending on the students' answers, you may wish to continue the discussion, especially if your school has begun a recycling program or if students live in communities where there are recycling programs already underway.

4. Which product has the most packaging? What is it made from -- cardboard (trees), plastic (fossil fuels -- oil), etc.?

6. What do you think about this packaging? What do you notice about it? (The goal is to learn what students understand at this point about what is desirable or necessary, undesirable and unnecessary, regardless of their source of information.)

E. **LOOKING AT COST:** The comparison needs to be as simple and clear as possible: have students add, subtract, multiply, and divide (see "Teacher Data Sheet") wherever appropriate. Explain that you did some math last night and found out the cost of a cup of each kind of popcorn. You had a wonderful math workout!

(Either have students do the math or tell them the following: one cup of every one of the 3 different kinds of popcorn cost less than 10 pennies, less than a dime. You would like them now to circle how many pennies they believe each one costs.

1. Go back to the record of hands on "Pre-Activity Question D" to see what students thought the popcorn would cost.
2. Hand out "Popcorn: How Much Does It Cost?" (The hand-out has 2 rows of 10 pennies in each row drawn beside the name of each type of popcorn.) Ask the students to circle the number of pennies they would need to buy one cup of each kind of popcorn.
3. After they finish, ask a student to record their answers on the board.
4. When you have all their estimates, let them lead a discussion about what they thought about when deciding their answers. Ask a student to record these factors.
5. Tell them that you are now going to show them what you found out last night when you did your math homework. Place the card with the price per cup in front of its respective kind of popcorn.

## DISCUSSION/QUESTIONS

A. What did you learn about popcorn today that you didn't know before?

B. What really surprised you about the three kinds of popcorn?

C. What did you learn about packaging today?

D. What else would you like to learn about popcorn that we didn't talk about today?

Depending on their answers, you may wish to continue the discussion or build on some part of it in other lessons.

# FURTHER STUDY:

A. This activity could be done with many different products -- food, clothing, household goods, etc. The important issue is to have students investigate products and how they are packaged.

B. A discussion of food additives, salt intake, and other nutrition topics could be the subject of a teacher-led class on healthful eating. See the November 18, 1991 issue of *Newsweek*, page 90, for a summary of the new food-labeling requirements spearheaded by Food & Drug Administration (FDA) Commissioner, David Kessler. Since labels will now have uniform serving sizes; total calories; calories derived from fat, calories derived from carbohydrates, etc. children can be taught to look for ingredients, amounts per serving, etc.

C. Microwave popcorn provides an excellent example of the solid waste produced in the packaging of so-called "convenience foods." The cost of the popcorn extends beyond the price at the grocery check-out. It continues in the price that the buyer's family pays to have waste picked up and delivered to a landfill. Ask students to name examples of other foods that have high amounts of packaging.

# ACKNOWLEDGEMENTS:

Our thanks to Mary Chadbourne for writing this activity.

## TEACHER'S DATA SHEET:

NOTE: Prices are from Kresse's Grocery Store, Bainbridge, Ohio, November 4, 1991

POPCORN:

1. **Snyder of Berlin: "Superpop Pack Butter Flavored Popcorn"**

   $1.29 for 8.5 ounces (by weight); equals 18 cups of popcorn

   Ingredients: popcorn, partially hydrogenated vegetable shortening (contains one or more of the following: soybean oil, cottonseed oil), peanut oil, salt, butter.

   Packaging: 1 polyethylene-coated cellophane bag with colored print (verified with John Hayes, Snyder's Potato Chips, Berlin, PA, telephone 1/814/267-4641); number of bags needed to equal a box of Microwave popcorn (see below) = 3 bags of prepopped popcorn; number of bags needed to equal a 16 ounce bag of popcorn from scratch = 3.6 bags of prepopped popcorn.

   ACTUAL COST PER CUP: $ .07/cup

   TOTAL WASTE GENERATED: 1 polyethylene-coated cellophane bag

   RECYCLABLES GENERATED: None

2. **Betty Crocker "Pop-Secret Light Microwave Popcorn"**

   $3.79 for 18 ounces (6 3-oz. bags); cooked, it equals 10 cups per 3-ounce bag or 60 cups altogether (manufacturer claimed 12 cups/bag: a test with complete popping of all kernels yielded 10 cups)

   Plus heat (microwave) -- This cost of the electricity to operate the microwave is not computed here

   Ingredients: Popcorn, partially hydrogenated soybean oil, salt, artificial and natural flavor color added, freshness preserved by TBHQ and citric acid (Call 1-800-231-0308 with questions)

   Packaging: Paperboard box (recyclable); each paper popcorn bag is wrapped in a polyethylene-coated cellophane bag; the paper bag holds 10 cups of popcorn (bag not recyclable -- oil & butter stained); 1 box, 6 polyethylene-coated bags and 6 paper bags in all

ACTUAL COST PER CUP: $ .06/cup

TOTAL WASTE GENERATED: Six 10-ounce paper bags (oil/butter stained); six polyethylene-coated cellophane bags

RECYCLABLES GENERATED: 1 paperboard box

3. **Seaway Popcorn**

$ .49 for 16 ounces; cooked, it equals 66 cups of popcorn

Ingredients: Popcorn

Packaging: 1 plastic bag (plastic type not marked; appears to be polyethylene, which is recyclable); holds 2 cups of unpopped corn

Also required:

**Mazzola Corn Oil**

$1.39 for 16 ounces; 3 T*/batch x 6 batches = 18 T = 1 cup & 2 T (1 1/8 cups) oil or $ .70

Ingredients: Corn oil

Packaging: 1 plastic bottle (PETE, No. 1 plastic) - recyclable

**Hillandale Farms Butter**

$1.65 for 2 cups; 3 T/batch x 6 batches = 18 T = 1 cup & 2T (1 1/8 cups) or $1.04

Ingredients: Butter

---

*T = Tablespoon; t = teaspoon

Packaging: Comes in a plastic coated paperboard box (not recyclable); 1 sheet of paper wraps each butter stick -- 4 sticks in all (paper not recyclable)

**Seaway Salt**

$ .33 for 3 cups (volume; 1 lb. 10 oz. = weight); 1 t/batch x 6 = 6 t = 2 T = .125 cup or $ .01

Ingredients: Salt, sodium silicaluminate

Packaging: 1 paperboard container (recyclable with aluminum pour spout removed; pour spout recyclable with mixed aluminum waste)

Plus heat (stove/corn popper) - The cost of electricity to cook the corn is not computed here

ACTUAL COST PER CUP: $ .03/cup

TOTAL WASTE GENERATED: Approximately 2 paper butter wraps (not recyclable); approximately half of a plastic-coated paperboard butter carton
RECYCLABLES GENERATED: One 2-cup polyethylene bag (popcorn); just over 1/2 of 16 ounce PETE bottle (oil); 1/32 of a paperboard salt container

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## STUDENT ACTIVITY SHEET

## "How Much Popcorn Is There?"

Names of Students in Your Group: ______________________________

______________________________________________

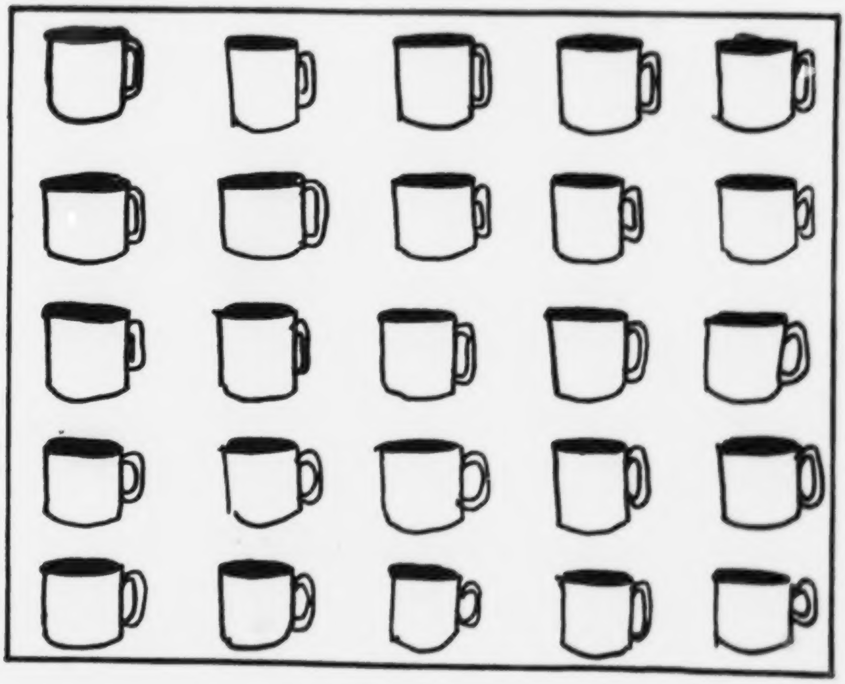
______________________________________________

______________________________________________

Below are pictures of cups to help you keep a record of how many cups of popcorn your group counts.

Counters: Count each cup

Marker: Circle a picture of a cup for every cup the Scooper in your group pours into the bag



STUDENT ACTIVITY SHEET

# "What's in My Popcorn Besides Corn?

Your Name: ________________________________

1. Draw a circle around the kind of popcorn you are studying:

   Prepopped popcorn

   Microwave popcorn

   Popcorn from scratch

2. Below is a list of INGREDIENTS you may find on the packages of Prepopped Popcorn, Microwave Popcorn, **or** on the packages of food used to make Popcorn from Scratch. Draw a circle around the letter of the words that you find on your package or packages:

   a. Popcorn
   b. Salt
   c. Butter
   d. Partially hydrogenated vegetable shortening
   e. Soybean oil
   f. Cottonseed oil
   g. Peanut oil
   h. Corn oil
   i. TBHQ
   j. Artificial and natural flavor, color
   k. Citric acid
   l. Sodium silicaluminate

## TEACHER NOTES: "What's in My Popcorn Besides Corn?"

For your information:

1. "Hydrogenation" is a process used to give plant oils a certain texture and/or shelf-life. It "artificially saturates them," that is, it hooks hydrogen atoms onto Carbon atoms; this makes the chemical bonds stronger and therefore it is harder for other chemicals to join them. To hydrogenate plant oils, food chemists add nickel as a catalyst to the oil and then expose the mixture to hydrogen gas. Then the nickel is filtered out. Plant oils are "partially hydrogenated" because total hydrogenation would make them brittle, which is an undesirable texture. (For more facts about food chemistry, see Harold McGee's *On Food and Cooking: The Science and the Lore of the Kitchen*, Charles Scribner's Sons, New York, NY, 1984. The above information on hydrogenation is based on his text on pages 603-4.)

2. The "natural color" agents often used for yellow/orange hues are "carotene" (from carrots) or annatto (coloring extracted from a tropical plant seed) -- McGee, p. 23.

3. Sodium silicaluminate is an "anti-caking agent," i.e., a chemical used to keep the salt crystals from clumping together.

4. TBHQ, according to a Betty Crocker spokesperson reached at their customer information number (1/800/231-0308) is "tertiary butyl hydroquinone." It is an anti-oxidant, a stabilizer for unsaturated fats which prevents them from combining with oxygen in the atmosphere and turning bad (e.g., when this happens to chocolate, its surface turns light brown).

5. "Artificial and Natural Flavor & Color" -- According to the Betty Crocker spokesperson at the 800 number, above, the company will not tell which of the following natural and artificial flavors are used in their microwave popcorn, because that is a proprietary recipe. However, the colors and flavors used are **among** those in the following lists that the Company provided:

   NATURAL INGREDIENTS: Beef extract, citric acids, lactic acids, malic acid, malt, malt syrup, malphol, and MSG (monosodium glutamate), sodium bicarbonate, turmeric, vanilla, and acetic acid

   ARTIFICIAL INGREDIENTS: Hydrolyzed vegetable protein, vanillan, disodium guanylate, adipic acid, and phosphates

## STUDENT ACTIVITY SHEET

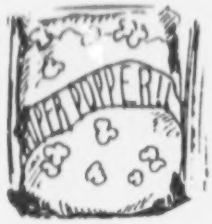
## "Popcorn Packages -- What Are They Made of & Where Do They Go Next?"

NAME: ______________________________

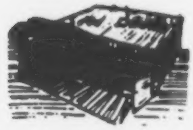
INSTRUCTIONS:

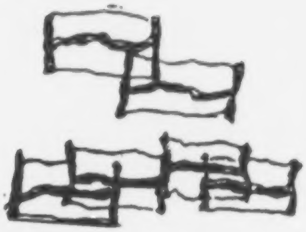
Put a "W" for WASTE under each item that cannot be recycled. Put an "R" under each item that can be recycled.

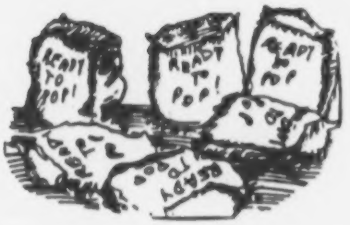
1. PREPOPPED POPCORN:


SUPER POPPERIN

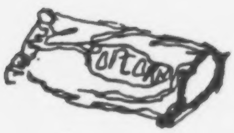
2. MICROWAVE POPCORN:

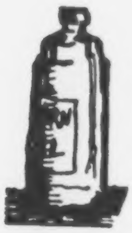


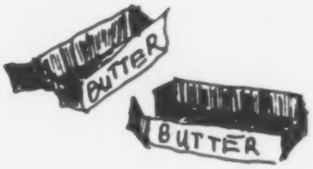


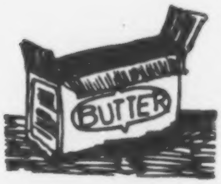

READY TO POP!
READY TO POP!
READY TO POP
READY TO POP

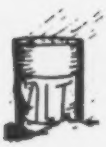
3. POPCORN FROM SCRATCH






BUTTER
BUTTER





BEST COPY AVAILABLE

## STUDENT ACTIVITY SHEET

## "Popcorn -- How Much Does It Cost?"

NAME: ________________________________

A. WHICH POPCORN COSTS MORE? DRAW A CIRCLE AROUND THE LARGEST AMOUNT OF MONEY:

1. A bag of Prepopped Popcorn costs $1.29.
2. A box of Microwave Popcorn costs $3.79.
3. A bag of Popcorn-from-Scratch, butter, salt, and oil cost $2.24

B. WHICH POPCORN GIVES THE MOST POPCORN? DRAW A CIRCLE AROUND THE LARGEST NUMBER OF CUPS:

1. A bag of Prepopped Popcorn has 18 cups.
2. A box of Microwave Popcorn has 60 cups.
3. A bag of Popcorn-from-Scratch has 66 cups.

C. NOW, WHICH GIVES YOU THE MOST POPCORN FOR THE LEAST AMOUNT OF MONEY? CIRCLE the NUMBER OF THE POPCORN THAT IS THE BEST BUY:

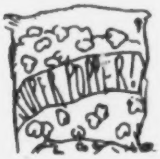
1. Prepopped Popcorn: 18 cups for $1.29
2. Microwave Popcorn: 60 cups for $3.79
3. Popcorn from Scratch, butter, oil, & salt: 66 cups for $2.24

D. We need over 50 cups of popcorn. How many bags of Prepopped Popcorn will we have to buy? (Remember: Each bag has 18 cups of popcorn in it.)

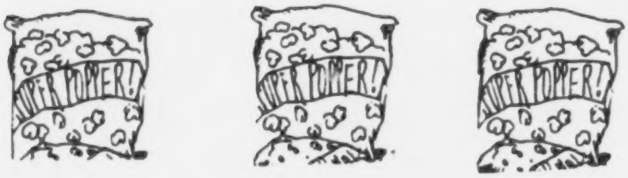
E. How much will it cost us to buy over 50 cups of Prepopped Popcorn? (Remember: Each bag costs $1.29.)

## IN PICTURES: HOW MUCH POPCORN IS THERE?

PREPOPPED POPCORN:

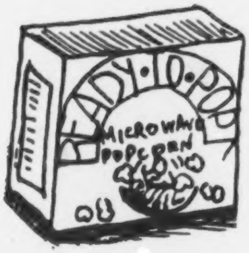

SUPER POPPER!

= 18 cups


SUPER POPPER!
SUPER POPPER!
SUPER POPPER!

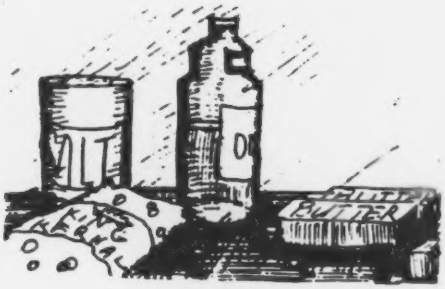
= 54 cups

MICROWAVE POPCORN


READY-TO-POP!
MICROWAVE POPCORN

= 60 cups

POPCORN FROM SCRATCH



= 66 cups

# IN PICTURES: WHAT'S IN MY POPCORN BESIDES CORN?

PREPOPPED POPCORN:

Ingredients: popcorn, partially hydrogenated vegetable shortening (contains one or more of the following: soybean oil, cottonseed oil), peanut oil, salt, butter.

MICROWAVE POPCORN:

READY-TO-POP
MICROWAVE POPCORN

Ingredients: Popcorn, partially hydrogenated soybean oil, salt, artificial and natural flavor & color added, freshness preserved by TBHQ and citric acid

POPCORN FROM SCRATCH:

Ingredients: Popcorn, corn oil, butter, salt

# IN PICTURES: POPCORN PACKAGES -- WHAT ARE THEY MADE OF & WHERE DO THEY GO NEXT?

PREPOPPED POPCORN:

| | | | |
|---|---|---|---|
| 1. | Polyethylene coated cellophane bag | RECYCLE? NO | WASTE? YES |

MICROWAVE POPCORN:

| | | | |
|---|---|---|---|
| 2. | Box: paperboard | RECYCLE? YES | WASTE? NO |
| 3. | 6 polyethylene coated cellophane bags | RECYCLE? NO | WASTE? YES |
| 4. | 6 butter/oil stained paper bags | RECYCLE? NO | WASTE? YES |

POPCORN-FROM-SCRATCH:

| | | | |
|---|---|---|---|
| 5. | 1 polyethylene bag | RECYCLE? YES | WASTE? NO |
| 6. | 1 polyethylene coated cardboard box | RECYCLE? NO | WASTE? YES |
| 7. | 2 paper butter wrappers, butter stained | RECYCLE? NO | WASTE? YES |
| 8. | 1 No. 1 plastic bottle (corn oil) | RECYCLE? YES | WASTE? NO |
| 9. | 1 Cardboard salt container | RECYCLE? YES | WASTE? NO |

## TEACHER'S ANSWER SHEET

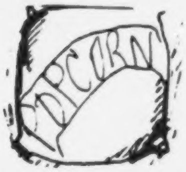
"Popcorn Packages -- What Are They Made of and Where Do They Go Next?"

1. Polyethylene coated bag - WASTE
2. Paperboard box - RECYCLE
3. Polyethylene coates cellophane bags - WASTE
4. Butter/oil stained paper bags - WASTE
5. Polyethylene bag - RECYCLE
6. Polyethylene-coated cardboard box - WASTE
7. Paper butter wrappers, butter stained - WASTE
8. No. 1 plastic bottle - RECYCLE
9. Cardboard salt container - RECYCLE

## IN PICTURES: POPCORN – HOW MUCH DOES IT COST?

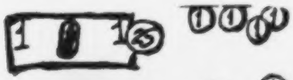
### FOR OVER 50 CUPS OF POPCORN

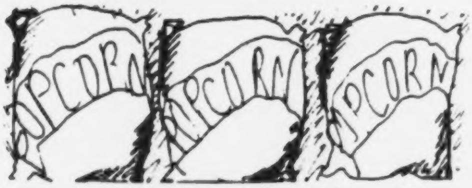
PREPOPPED POPCORN:



Per package (18 cups):

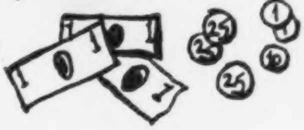
1 BAG =



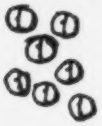

POPCORN
POPCORN
POPCORN

For three packages (for 54 cups):

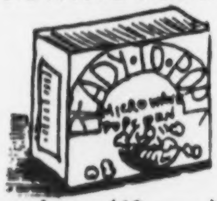
3BAGS =


1
1
1
25
25
25
1
1
10

COST/CUP =

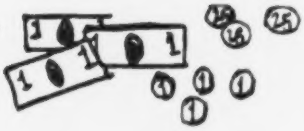


MICROWAVE POPCORN:

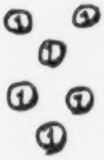

READY-TO-POP
MICROWAVE POPCORN

Per package (60 cups):

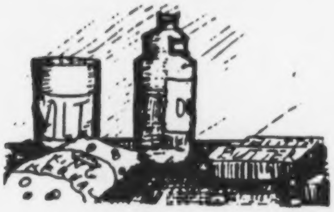
1 BOX =


1
1
1
10
10
25
1
1
1
1

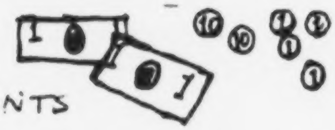
COST/CUP =



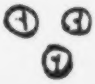
POPCORN FROM SCRATCH


SALT
OIL
BUTTER

1 BAG =
+ OTHER
INGREDIENTS


1
1
10
10
1
1
1
1

COST/CUP =



Per package (66 cups -- using all of the popcorn, half a package of butter, half a bottle of oil, and 2 tablespoons of salt):

## TEACHER NOTES: "IN PICTURES" ACTIVITY SHEETS

1. These handouts will allow you to work with students to learn their understanding about money values, measurements, and overall value when comparing quantity to price.

2. Because children will have differing degrees of understanding about these value questions, you can use actual money on the table in front of each of the three full bags of popcorn (54 cups of Prepopped, 60 cups of Microwave, 66 cups of Popcorn-from-Scratch). The money will add concreteness of the idea of cost and value for them, since most children -- if not all -- will have purchased products of some sort and will have some idea about the worth of a dollar compared to a quarter, a quarter compared to a dime, etc.

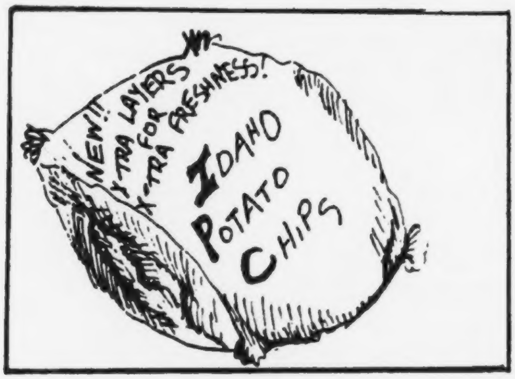
3. Some children may be confused about why 3 bags of Prepopped Popcorn are needed, while only 1 box of Microwave Popcorn and 1 set of ingredients for Popcorn-from-Scratch are needed.

4. Altogether, these "In Pictures" sheets will help you to teach them relative money values, relative value by volume, relative vale by waste and recyclables produced, etc.

# PACKAGING: WHAT A WASTE!

**Subjects:** Mathematics, environmental science, home economics, economics

**Format:** Class discussion and analysis; could be adapted for individual and student team assignments


NEW!! X-TRA LAYERS FOR X-TRA FRESHNESS!
IDAHO POTATO CHIPS

**OBJECTIVES:** The students will be able to (1) describe the relationship between cost and the amount of packaging and processing of food products, (2) identify environmental and waste management problems associated with packaging, and (3) consider criteria for selecting and purchasing products which waste less energy and fewer resources.

**METHOD:** Students examine samples of various product packages and investigate the price and relative amounts of processing and packaging of different food items in a local grocery store.

**BACKGROUND:** The average American purchases and disposes of about 660 pounds of packaging each year. The annual national total comes to 92 billion aluminum and steel cans, 42 billion glass bottles and jars, and 16 billion plastic containers. While over 60% of all aluminum beverage cans are recycled, the recovery rates for steel, glass, and plastic containers are considerably lower. The majority of this material ends up in landfills. Overall, packaging makes up an estimated 30% of all the material that is landfilled.

A large portion of used packaging is discarded as litter on roadways and beaches and in cities and parks. A survey conducted in 1988 in Florida found more than 2,500 discarded packaging items per mile of interstate roadway. Packaging litter has adverse effects on tourism and harms and kills wildlife.

In addition, the packaging manufacturing/distribution/retail process generally fails to account for the cost of package disposal. Since this cost is not included in the cost of the product, the product sells for less than it would if the cost for disposal was included. However, consumers do eventually pay for the costs associated with package disposal in the form of higher taxes for garbage collection, landfill and incinerator operation, and litter collection.

Even without the inclusion of disposal costs, increased packaging does increase the cost of products. Generally, packaging accounts for about 10% of the cost of a product. If consumers can relate their purchase costs to the amount of waste generated by packaging, they will realize they can save money by purchasing products with less packaging, buying products in bulk, and selecting products with recyclable or reusable packaging.

In addition to adverse economic and waste management impacts, packaging can also have other negative environmental impacts. The manufacture of packaging consumes vast amounts of resources and energy. In 1974, the Environmental Action Foundation published research showing that the energy used to produce the packaging used annually by a large fast food restaurant chain was equal to the amount of energy required to meet the needs of the people of Boston, Washington, San Francisco, and Pittsburgh for a year.

## MATERIALS:

- Samples of different types of food packaging (paper boxes, metal cans, plastic bottles and bags, glass containers, foil wrappings, styrofoam trays, etc.)
- "A Spud by Any Other Name" chart (transparency or one per student)

## PROCEDURE:

A. Introduce the activity by passing around samples of different types of food packaging. Ask students to identify the functions of food packaging (e.g. hygiene, containment, and preservation.) Next ask students if they think the amount and type of packaging affects the cost of different food products. Finally, ask students if they think packaging is necessary for all types of food.

B. Distribute or project "A Spud by Any Other Name" handout and ask the following questions:

   1. Which forms of the potato are most highly processed and packaged?

   2. Which forms are most expensive per pound?

3. Which form of potato would you purchase if you were interested in reducing solid waste or saving money?

C. Divide students into groups of 2-3. Instruct each group to choose a fresh food item to investigate, such as potatoes, apples, peanuts, tomatoes, or corn. Have them develop a chart like "A Spud by Any Other Name" that contains the following categories: Product Name, Package Size, Unit Price, Price Per Pound.

D. Take students to a grocery store (or ask students to go independently after school). Ask students to complete their charts for fresh forms of their product as well as 5-10 items that are processed forms of the product (frozen, canned, dehydrated, etc.).

**DISCUSSION/QUESTIONS:** After all groups have collected their data, conduct a whole class discussion addressing the following questions:

A. Which form of your food item is most expensive per pound? Why?

B. Which form do you think takes the most energy to produce?

C. What relationships are there among cost and amount of processing and packaging of products?

D. Which packaging do you think is least wasteful of energy and resources? Which is most wasteful?

E. Does the product need packaging?

F. What do people do with the packaging after they use the product?

G. Which packaging weighs the least per pound of product; takes up the least space in the landfill; decomposes most or least quickly; doesn't produce toxic materials when it decomposes?

H. Which of these products will you buy in the future? What criteria will you use for making your decisions about what to buy and what not to buy?

I. What percentage of the cost of packaged foods do you think is due to packaging?

J. Which of your favorite foods could you buy without packaging?

K. How can packaging of foods be reduced?

L. Conclude the activity with a discussion of pertinent background information regarding packaging and its environmental and economic impacts.

## FURTHER STUDY:

A. Ask students to rank/order the food products investigated from "most packaging/processing" to "least packaging/processing" and construct a graph illustrating the relationship between cost and packaging. Then ask them to interpret the graphed relationship in one to two sentences.

B. Ask students to identify two environmental and/or waste management problems associated with packaging.

C. Ask students to describe two criteria for selecting and purchasing food products which waste less energy and resources.

D. Prepare a revised "A Spud by Any Other Name" chart and leave the price per pound column blank. Ask students to calculate the price per pound for each product.

E. Assign students to prepare a personal plan for reducing the amount of excess packaging purchased.

F. As a problem-solving activity, ask students to brainstorm ways to convey findings to companies using excessive packaging. How can students address the issue as a mutual problem? What are likely to be the most effective communications? Assign them to test their ideas.

## ACKNOWLEDGEMENT:

Our thanks to the Florida Department of Education for its permission to use this activity from its *4Rs Project*.

# A SPUD BY ANY OTHER NAME

| PRODUCT | PKG SIZE | PRICE | PRICE/LB |
|---|---|---|---|
| Fresh Idaho Potatoes | 5 lbs | $1.19 | $0.24 |
| Fresh Idaho potatoes | 10 lbs | $1.58 | $0.16 |
| Russet Baking Potatoes | loose | $0.39 | $0.39 |
| Finast Canned-sliced Potatoes | 16.0 oz. | $0.48 | $0.48 |
| Finast Canned-whole Potatoes | 16.0 oz. | $0.48 | $0.48 |
| Ore Ida Microwave Crinkle Fries-frozen | 3.5 oz. | $0.55 | $2.51 |
| Ore Ida Microwave Tater Tots-frozen | 4.0 oz. | $0.55 | $2.18 |
| Ore Ida Hash Brown Patties-frozen | 24.0 oz. | $1.49 | $0.99 |
| Ore Ida Crispy Crowns-frozen | 30.0 oz. | $1.79 | $0.95 |
| Ore Ida Hash Browns (Southern Style)-frozen | 32.0 oz. | $1.49 | $0.74 |
| Ore Ida Golden Crinkle Fries-frozen | 32.0 oz. | $1.79 | $0.89 |
| Ore Ida Golden Crinkle Fries-frozen | 5.0 lbs. | $3.69 | $0.73 |
| Ore Ida Shoestrings-frozen | 40.0 oz. | $2.49 | $0.99 |
| Lay's Potato Chips-bag | 6.5 oz. | $1.49 | $3.67 |
| Lay's Potato Chips-bag | 14.5 oz. | $2.50 | $2.76 |
| Hungry Jack Instant Mashed-box | 8.0 oz. | $1.09 | $2.19 |
| Hungry Jack Instant Mashed-box | 13.3 oz. | $1.59 | $1.91 |
| Hungry Jack Instant Mashed-box | 26.7 oz. | $2.59 | $1.55 |

**Prices gathered at Finast in Cleveland on September 23, 1991.**

# HOW TO CALCULATE BTUs PER CONTAINER

**Subjects:** Mathematics, science, chemistry, physics, home economics

**Format:** One class period; homework assignment for calculations optional

TOASTY OATS CEREAL
SOUP
MOO FARM MILK

**OBJECTIVE:** Students will (1) compare the energy used for the package or container with the energy actually in the food itself; (2) calculate how much energy is used to produce the food containers they bring to class; (3) understand, in general terms, how much energy can be conserved by recycling packaging materials and that conservation of energy is as important as finding alternative sources of energy -- energy can be conserved by careful buying and by recycling.

**BACKGROUND:** The unit of heat energy used in science is the calorie (cal.), also called gram-calorie or small calorie. It is defined as the amount of heat energy needed to raise one gram of water 1° Centigrade.

In nutrition, the unit of food energy is the Calorie (Cal.), also called kilogram-calorie, or great calorie. It is defined as the amount of energy needed to raise one kilogram of water 1° Centigrade. It is equal to 1,000 calories.

The small "c," capital "C" difference is important. Only the nutritional calorie uses capital C.

Engineers use a different heat energy standard called the British thermal unit (Btu). It is defined as the quantity of heat required to raise the temperature of one pound of water 1° Fahrenheit. One Btu = 250 calories. (NOTE: 1 pound = 454 grams Centigrade = 5/9 [Fahrenheit - 32]; 1 kilogram = 2.2 pounds)

# MATERIALS:

- Containers (brought by students)
- Charts titled "Btu/Calorie Comparison Chart for Manufactured Goods," "Energy Used by Packaging Materials" and "Environmental Benefits of Recycling"
- Calorie counter booklet (these are available at grocery check-out counters for under $1.00; they may also be available in a health textbook)
- Scale - capable of weighing an ounce up to 2-5 pounds

# PRE-ACTIVITY QUESTIONS:

A. What does Btu stand for?

B. Which takes more energy to produce: an aluminum can or a tinned can?

# PROCEDURE:

A. Ask students to weigh the containers they have brought to class. (Where required, cut packaging into smaller pieces and stack or weigh pieces separately to get the total package weight.) Give them the chart titled "Btu/Calorie Comparison Chart for Manufactured Goods" (at the end of the activity), and ask students to calculate the energy in Btus used to produce each container.

B. Look up the Calories of the food that came in the container and compare the energy used to produce the container with the energy that the food contains. Use a Calorie counter booklet or the USDA handbook, "Nutritive Value of American Foods for Caloric information." (See Bibliography)

C. Other ideas: Since aluminum is so light, students often wonder if making an aluminum can uses fewer Btu's than making a tinned steel can. Find a steel can of the same size and weight as an aluminum can. Determine if the aluminum can used fewer Btu's than the steel can. (Use the chart titled "Energy Used by Packaging Materials" at the end of the activity.)

D. Determine how much energy is saved by buying a product in one large container rather than in several smaller ones: use milk cartons/jugs, cereal boxes, cans, etc. Compare nutrition received to energy needed to produce the container - 1 large versus several smaller containers. (Again, use the chart titled "Energy Used by Packaging Materials.")

E. By referring to the chart titled "Environmental Benefits of Recycling," determine how much energy can be conserved by recycling some types of packaging material.

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Letcher, Robert Cowles, & Mary T. Sheil, "Source Separation and Citizen Recycling," in William D. Robinson, ed., *The Solid Waste Handbook*. New York, N.Y.: John Wiley & Sons, 1986.

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Sherman, Nancy J. "Foodservice Disposables and the Solid Waste Challenge." *Resource Recovery*. February 1989, Vol. 3, No. 1.

U.S. Department of Agriculture, Washington, D.C. (Catherine Adams) *Nutritive Value of American Foods: In Common Units*. Agricultural Research Service, Agricultural Handbook #456 (expanded, detailed version, 1975) or #72 (concise edition, 1981).

## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology for its permission to use/adapt this activity from *A-Way with Waste*.

## Btu/Calorie Comparison Chart for Manufactured Goods*

| PRODUCT | BTU/pound | BTU/gram | Calories/pound |
|---|---|---|---|
| Paper | 20,400 BTU/lb | 44.9 BTU/gm | 5,141 cals/lb |
| Glass | 7,628 BTU/lb | 16.8 BTU/gm | 1,922 cals/lb |
| Steel | 14,795 BTU/lb | 32.6 BTU/gm | 3,728 cals/lb |
| Aluminum | 98,616 BTU/lb | 217.2 BTU/gm | 24,851 cals/lb |
| Plastic | 18,554 BTU/lb | 40.8 BTU/gm | 4,673 cals/lb |

* Sources: Data supplied to Center for Science in the Public Interest by Research Triangle Institute under EPA Contract #68-01-0791

## Energy Used by Packaging Materials

| Material | kcal/lb** | kcal/oz | kcal/gm | BTUs/lb | BTUs/gm |
|---|---|---|---|---|---|
| Paper | 5,131 | 321 | 11.4 | 20,373 | 44.9 |
| Glass | 1,918 | 120 | 4.2 | 7,611 | 16.6 |
| Steel | 3,724 | 233 | 8.3 | 14,778 | 32.6 |
| Aluminum | 24,837 | 1,552 | 54.7 | 98,560 | 217.1 |
| Plastic | 4,670 | 292 | 10.3 | 18,532 | 40.8 |

** kcal: 1 kcal = 1 Calorie

## Environmental Benefits of Recycling***

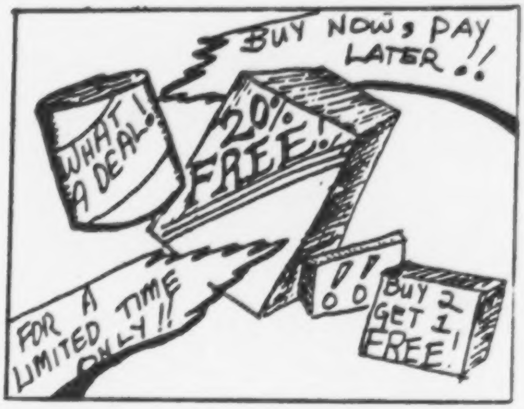
| | Environmental Benefits of Recycling | | | |
|---|---|---|---|---|
| Environmental Benefit | Aluminum | Steel | Paper | Glass |
| Energy use reduction | 90-97% | 47-74% | 23-74% | 4-32% |
| Air pollution reduction | 95% | 85% | 74% | 20% |
| Water pollution reduction | 97% | 76% | 35% | N/A |
| Mining wastes reduction | N/A | 97% | N/A | 80% |
| Water use reduction | N/A | 40% | 58% | 50% |

***Statistics are from *R. Cowles's and M. Sheil's "Source Separation and Citizen Recycling," in The Solid Waste Handbook*, edited by Wm. D. Robinson, New York, NY: John Wiley & Sons, 1986.

# WHY DO I BUY IT?

**Subjects:** Business education, home economics, English, speech, art, social studies, environmental education, economics

**Format:** Student teams, individual students; interviewing customers in stores & reporting findings


BUY NOW, PAY LATER!!
WHAT A DEAL!
20% FREE!
FOR A LIMITED TIME ONLY!!
BUY 2 GET 1 FREE!

**OBJECTIVE:** Careful buying is the first step in solving the problem of too much solid waste: consumers should consider waste disposal and recycling when deciding what to buy. Students will (1) find out the reasons why people in a grocery store buy certain food products, (2) try to determine the influence of packaging on consumer choices, and (3) determine if consumers consider waste disposal and recycling when making buying decisions.

**METHOD:** Students will conduct interviews of people in a grocery store to learn what factors govern their buying decisions.

**BACKGROUND:** Depending on the class in which this activity is used, the teacher can focus on relevant material. For example, an art instructor might discuss the research done to date on the appeal of certain color combinations; business education teachers might address the issue of how grocery store marketing combines package color, size, and location on shelves; home economics teachers might emphasize nutritional and economic topics, etc. This is an activity with ample opportunity for involving interdisciplinary subject matter.

**MATERIALS:** The only materials required are a pencil, clipboard, and the "Purchasing Questionnaire" at the end of this activity.

## PRE-ACTIVITY QUESTIONS:

A. Ask students how frequently they consider packaging when purchasing an item.

B. Ask them what they believe are the main reasons for people's purchases in the grocery store.

## PROCEDURE:

A. Ask the students to develop a questionnaire to interview people in a grocery store about the reasons they buy the items in their grocery carts. (The following is an example.)

Sample Questionnaire

Which of the following factors influenced your decision to buy this product?

1. The cost per pound
2. The convenience in preparation
3. You saw it advertised
4. High nutritional value
5. Lack of artificial coloring, flavoring, or preservatives
6. The packaging is reusable/recyclable
7. You are having company
8. Trying something new
9. Catchy packaging -- visually attractive
10. A friend recommended it
11. It was on sale
12. Buying it for the kids

13. Uses less packaging than other brands

14. You're familiar with the brand

15. You've used this produce before

16. Etc.

B. Instruct the students to ask the shoppers:

  1. Does the recyclability of the product or its package play a part in determining what you buy?

  2. When buying, do you think of how easy or difficult the product or its package will be to dispose of when you are finished with it?

C. Assign students to conduct polls for homework.

Try to poll four or five shoppers and ask questions concerning six or seven items in their carts.

D. Analyze and chart the results of the interviews.

## DISCUSSION/QUESTIONS:

A. Which were the most common reasons for buying a food product?

B. How often was recyclability taken into account?

C. Were people concerned about waste disposal when deciding what to buy?

**FURTHER STUDY:** Assign students to interview their own families to find out why certain products have been purchased for home use. Assign individual students or teams to survey articles in the references below and report back to the class on their findings.

## SOURCES:

Bradburn, Norman W. *Polls and Surveys: Understanding What They Tell Us.* San Francisco, Ca.: Jossey-Bass, 1988.

Freeman, David J. Ed. *Key Social Issues for Packaging in the 1980's.* New York: AMACOM, 1980.

Peterson, Christina, et al. *Energy, Food and You, Elementary Guide.* Seattle, WA.: Washington State Office of Environmental Education, Northwest Section, 1980.

Powell, Jerry. "Packaging Under Attack: The Waste War." *Resource Recycling.* May-June, 1989, Vol. 8, No. 2.

## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology for its permission to use this activity from its publication, *A-Way with Waste.*

# PURCHASING QUESTIONNAIRE

Place a check under the "Reason Bought" for all reasons that apply to each product.

| Reason Bought | Product/Brand | Product/Brand | Product/Brand | Product/Brand | Product/Brand | Product/Brand |
|---|---|---|---|---|---|---|
| Used Before | | | | | | |
| Cost | | | | | | |
| Convenience | | | | | | |
| Advertising | | | | | | |
| Nutrition | | | | | | |
| No Artificial | | | | | | |
| Reusable/Recyclable | | | | | | |
| Company Coming | | | | | | |
| New Packaging | | | | | | |
| Friend Recommended | | | | | | |
| On Sale | | | | | | |
| Kids Asked | | | | | | |
| Less Packaging | | | | | | |
| Familiar Brand | | | | | | |

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# WHAT DO I DO WITH IT NOW?

**Subjects:** Science, mathematics, citizenship, environmental science

**Format:** One class period

COLA
100% JUICE
MILK
APPLE JUICE

**OBJECTIVE:** The objective of this activity is to teach students what beverage containers are made of and which of them can be recycled.

**METHOD:** The teacher will bring in samples of each of the beverage container types to display them and to have students test cans for magnetism and inspect plastic containers for their identifying numbers.

**BACKGROUND:** Students may be recycling at home if their city has a recycling program. Others may have parents who are committed enough to recycling that even though there is no program in place, they take recyclables to a "drop off" center. Beverage containers for milk, juice, and soft drinks are familiar to children and are therefore a simple and effective means for introducing recycling.

Note that steel is magnetic, but aluminum is not. However, some bimetal aluminum beverage cans may have a **steel** body and aluminum tops and bottoms. The coding system for marking plastics is listed on the "Teacher Answer Sheet and Information on Plastics" at the end of this activity. Number codes are placed on the bottom of plastic containers in a small triangle.

Once recyclables are identified, the teacher can also introduce the question of what to do about containers that are not recyclable. Currently they must be disposed of with waste that is either incinerated or landfilled. Since both of these choices are less desirable than "The Three Rs -- Reduce, Reuse, Recycle" -- teachers can discuss with students what else could be done to eliminate these containers from the waste stream.

This discussion will lead to the idea of "choice" when buying products. From the standpoint of waste reduction, it is preferable to buy milk in the plastic "number 2" jug (high density polyethylene) than it is to buy it in the gabled milk carton, which is unrecyclable because the cardboard is coated with plastic (polyethylene), although a new process now operating on a limited basis in Kentucky is separating the plastic coating from the cardboard.

Students become wiser consumers with this information, and they can help educate parents and relatives about the best choices to make at the store to help reduce solid waste and save resources.

# MATERIALS:

* Contact the waste management or recycling office in your area for a directory of recyclers in the community. They often have free lists of many resources on recycling and solid waste issues.

  Ask the county if it will send enough sets for your class so that you can provide each student's family with a copy. This allows families without recycling programs in their communities to find convenient drop-off centers for their recyclables.

* Magnets (more than one allows students to test cans in groups) - a simple bar magnet or even a refrigerator magnet will do.

* Empty, rinsed beverage containers (numbers in parentheses indicate the plastic code found on the bottom of the container): plastic milk jugs (No. 2), 2-liter pop bottles (No. 1), bi-metal pop cans (Pepsi and 7-Up use them), aluminum pop cans, large metal juice cans or tuna or soup cans (steel), large glass juice bottles, gabled cardboard milk cartons, aseptic juice boxes, glass pop bottles, returnable (return deposit) glass pop bottles.
* Student handout titled "What's It Made of & Can I Recycle It?"

* "Teacher Answer Sheet and Information on Plastics"

# PRE-ACTIVITY QUESTIONS:

A. Ask children how many of them recycle at home.

B. Ask them what things they recycle.

C. Ask those who don't recycle if they would like to learn how to recycle.

## PROCEDURE:

A. Tell the students that today you will look at containers that hold things we drink. The purpose is to make sure they know what these containers are made of so that they can recycle them correctly or put them in the waste container if they cannot be recycled.

B. Divide the students into as many groups as you have magnets and sample containers.

  1. Ask them if they know what a magnet is. (Possible answers: "Something that sticks to metal," "a decoration on the refrigerator," "a black piece of metal," etc.)

  2. Once you have established that magnets attract ferrous metals, ask them what kind of metals there are (steel, iron, aluminum, copper, brass, etc.)

  3. Does a magnet attract all these metals? (No -- only steel and iron)

C. Tell them that you are now going to test the three kinds of cans to see if they are "magnetic." Tell them that some cans have only magnetic metal, some have magnetic and non-magnetic, and some only non-magnetic. Students should test the sides and the top and bottom of each can for magnetism. (Make sure that each group has a steel can, a bi-metal can, and an aluminum can.)

Tell them that all of these cans can be recycled.

D. Ask students what they discovered. Tell them that some recyclers want these different kinds of cans separated from each other. Others separate them with large magnets at the recycling site. Some sites may only take aluminum and not steel: aluminum is worth more because it takes more energy to manufacture and it is very efficient to recycle. Only 10% of the energy needed to make a can of virgin aluminum is needed to make one of recycled aluminum.

E. Next, let the children examine the 2-liter pop container and the plastic milk jug. Ask how the containers differ from each other. (No. 1 is clear and No. 2 is not). Tell them that most plastic containers have a number inside a triangle on the bottom. Ask them to look at the bottoms of the containers to see if they can find a triangle and a number. What did they find?

Tell them that both of these containers -- and other plastic containers marked with No. 1 and No. 2 -- can be recycled.

Other plastics can be recycled, but they are not as commonly found as these two and they are usually not used for beverage containers.

F. Next look at the glass containers: the large glass juice jar, the small glass pop bottle, and the returnable (return deposit) bottle. Ask the children what differences they notice about them. (For example, the reusable glass pop bottle is heavier than the recyclable glass pop bottle; there is a difference in their tops: the recyclable one is "threaded" for a screw-on cap, while the reusable bottle has a thick lip around the top for setting on a cap that is then crimped or squeezed to seal it.)

Ask children who are recycling at home if they separate the colors of glass -- brown, green, and clear. (Some recyclers require it, while others do not.) It is a question that families should ask when beginning to recycle. Explain that "recycling" glass means crushing it into small pieces called "cullet," melting it down, and reshaping it into new glass objects. Explain that returnable bottles are washed (sterilized to make them germ free) before they are refilled. Explain that two of the bottles are recyclable, while one is returnable.

However, all glass bottles with lids or with other seals could be "reused" at home once they were washed carefully. Ask children if anyone in their family reuses these containers. What do they put in them?

G. Finally, ask the children to look at the two plastic-coated cardboard containers, one for milk and one for juice. Ask them if they can be recycled. (Ask them why they believe "yes" or "no.")

After collecting their answers, explain that at this time they cannot be recycled. The plastic coating on the cardboard prevents it from being mixed with plain cardboard. These containers must be thrown in the waste container. They then go to an incinerator or to a landfill.

Explain that an incinerator is a large building where waste is burned. A landfill is a large area of land where waste is dumped and then covered with soil. Explain that things that are burned or landfilled can never be used again, but things that are recycled can be used again many times.

It is better to recycle and reuse than to incinerate and landfill because the first two save our resources and energy. In addition to using up the resources forever, incinerators can cause air pollution and landfills use up valuable space and sometimes leak their contents into our drinking water.

H. Ask students if they believe it might be possible to change what containers they use at home, if they use milk and juice cartons.

What could they tell their parents or relatives that might make them buy recyclable containers?

I. After answering students' questions, ask them fill out the activity sheet, "What's It Made of & Can I Recycle It?"

## FURTHER STUDY:

A. Have your community's recycling coordinator come in to speak to your students about how to recycle. Other materials besides plastic, glass, and metal (i.e., newspaper, cardboard, paperboard cereal/cracker boxes, etc.) can be covered.

B. For a mathematics assignment for more advanced students, ask them to check the quantity and the price of milk in a grocery store for both quart, half gallon, and gallon containers in plastic-coated cardboard versus No. 2 plastic milk jugs (NOTE: not all stores may carry quart and half-gallon jugs). Was there a difference in price? What might make the costs differ?

## ACKNOWLEDGEMENTS:

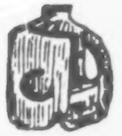
Our thanks to Mary Chadbourne for writing this activity.

## What's It Made of & Can I Recycle It?

**Beside each picture is a list of words. Circle the letter that tells what each container is made from.**

**Below each picture are the words "Can I recycle it? Yes No" Circle the correct answer.**

1.



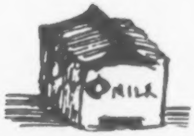
a. glass b. plastic c. steel

d. aluminum e. plastic & cardboard

**Can I recycle it?**

**Yes No**

2.



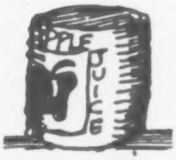
a. glass b. plastic c. steel

d. aluminum e. plastic & cardboard

**Can I recycle it?**

**Yes No**

3.



a. glass b. plastic c. steel

d. aluminum e. plastic & cardboard

**Can I recycle it?**

**Yes No**

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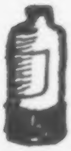
4.



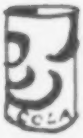
a. glass b. plastic c. steel

d. aluminum e. plastic & cardboard

**Can I recycle it?**

**Yes No**

5.



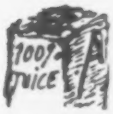
a. glass b. plastic c. steel

d. aluminum e. plastic & cardboard

**Can I recycle it?**

**Yes No**

6.



a. glass b. plastic c. steel

d. aluminum e. plastic & cardboard

**Can I recycle it?**

**Yes No**

# TEACHER ANSWER SHEET AND INFORMATION ON PLASTICS

**"What's It Made of and Can I Recycle It?" -- Answers:**

1. Yes; b (HDPE milk jug - No. 2 plastic)
2. No; e (gabled milk carton made of plastic-coated cardboard)
3. Yes; either c or d (juice can of either steel or aluminum)
4. Yes; b (PETE 2-liter pop bottle - No. 1 plastic)
5. Yes; d (aluminum pop can)
6. No; e and d (plastic and cardboard aseptic juice box; also contains some aluminum)

**Information on Plastics:**

Newer plastic containers -- newer containers are marked by the manufacturers with a recycling triangle containing a number and abbreviation so that consumers can identify the type of plastic. Check with your community recycling program or drop-off center to find out which plastics they will take.

The most commonly recycled plastics are those labeled with a 1 or a 2, particularly liter pop bottles and milk jugs, because they are found in the greatest abundance in the waste stream. They are easily rinsed, unlike a plastic bottle containing dish detergent, motor oil, or other substance.

* PETE or PET: polyethylene terephthalate (#1 plastic: 2-liter soft drink bottles, body portion only)

* HDPE: high density polyethylene (#2 plastic: gallon jugs for milk, cider, or distilled water; base cups of 2-liter soft drink bottles)

* PVC: polyvinyl chloride (#3 plastic: Saran wrap, imported mineral water bottles, plastic drain pipe)

* LDPE: low density polyethylene (#4 plastic: plastic shopping bags, bread wrappers, frozen food bags, milk bottle caps)

* PP: polypropylene (#5 plastic: food containers, laboratory bottles, medicine bottles, some yogurt and margarine containers)

* PS: polystyrene (#6 plastic: foam coffee cups, plastic picnic cutlery, foam packing "peanuts," egg cartons, clear plastic drinking cups, video cassette cases)

# LITTER: WHOSE PROBLEM IS IT?

**Subjects:** Science, citizenship, social studies, health, language arts, art

**Format:** Two or three class periods: a discussion followed by a field walk around the school grounds or adjacent neighborhood, and a follow-up discussion and/or art exercise

**OBJECTIVE:** To introduce children to these concepts: (1) Litter is resources out of place; (2) we all have a responsibility for taking care of Earth's resources, including litter; and (3) children doing their part to keep the environment clean can be models to adults and other children on how to behave to make the environment safer and cleaner.

**METHOD:** The teacher will lead a discussion about "picking up after oneself," about how children feel about litter in their environment and how they feel about cleaning up after others. Then, the class will go on a litter pick-up around the school grounds or the adjacent neighborhood. As an option, the teacher may wish a third class period to recap the discussion and litter pick-up by having the children write, draw, or report to the class orally about their reactions.

**BACKGROUND:** Teachers and parents have attested to the effectiveness of children in moving their schools and parents to start recycling efforts. When children state beliefs about what is good for the environment, when they ask adults to become involved in helping to do the right thing, adults often comply. The same conviction that results in school and home recycling also applies to litter collection and litter prevention in the neighborhoods. If children understand that litter is often recyclable, they can understand the reason for separating it from the actual waste stream and collecting it for a recycling facility.

When litter is picked up and put where it belongs, with recyclables or in the trash, there are other benefits: less harm to humans and wildlife (e.g., children cutting themselves on broken glass, birds and other animals becoming entangled in plastic bags and beverage can yokes); a neat-looking yard, neighborhood, or school grounds. Resources in their proper place, safety, and neatness are values that children can understand when put in terms familiar to them.

Children involved in litter clean-up at school and who learn the importance of managing resources are more likely to grow to adolescents and adults who will also make sure that litter is managed in the home and neighborhood.

One child picking up a potato chip bag and putting it in the trash or an aluminum can and putting it in an aluminum can recycle container can be a powerful agent of change to others who observe the action: peers, older children, and adults. Even though children know that they did not produce the litter, as their knowledge about recyclables versus waste increases, they can by action and example be good resource stewards. Children who feel strongly about having orderly surroundings can assert some control over them by picking up litter when they see it. The result is an assertion of individual power in having their space a little more cared for, a little cleaner.

Finally, not all children will share the values of order and neatness. They may not come from homes where these are practiced. In addition, clutter can be fascinating: who knows what one might find in an overturned trash can? The important points to remember are that children come from a great variety of cultures and values, and it is important to respect their differences. By emphasizing the importance of putting recyclables where they can be used again, you can appeal to a different value besides neatness: that of helping to use materials over and over again so that we don't run out of resources.

For younger children this may be a stretch of the imagination, but environmental ethics must begin early. You can reinforce the lesson daily in your own classroom practices of recycling, managing waste well, and reducing waste.

## MATERIALS:

* A bagful of litter that the teacher has collected nearby (schoolyard, neighborhood)

* Plastic gloves (or plastic sandwich baggies to use as gloves) for students

* Collection bags for litter collected on the litter-walk

* Depending on follow-up activities after the litter pick up, the teacher may wish to make art materials available and/or paper and pencils for writing assignments

* Student's handout of "Litter and What to Do with It"

- Teacher answer sheet on "Litter and What to Do with It"
- A classroom aide, parent, or other responsible adult to help monitor the students and what they are picking up while they are outdoors

**PROCEDURE:** First find out what your students' attitudes are toward the environment:

A. Ask, "If you see an empty pop can on the sidewalk, what do you do?" (Some possible answers: Play with it -- kick it, play catch with it; leave it, pick it up and throw it in the trash, keep it to put in the pop can recycling container)

If children said they would leave the can on the ground, ask them why they would do so. (Some possible answers: It's dirty; I didn't do it, someone else did; they pay other people to clean up trash; it could be dangerous)

Ask, "What is recycling?" "What happens to things that are recycled?" Write the word "recycle" on the board.

B. Ask, "How do you feel when you see trash in the street, in the school yard? Or when you see someone throwing trash on the ground, out a car window, or even trash blowing out the back of a pick-up truck?" (Some possible answers: It doesn't matter; I don't like it because it looks dirty; it makes it look messy; it makes me mad; I don't care; I don't like it but I can't do anything about it)

C. Ask, "What do we call cans, paper, plastic bags, and garbage that lie around the street and highways and yards?" (Look for the term "litter." Some possible answers: trash, garbage, litter). Write the word "litter" on the board.

D. Ask, "Is litter good for anything?" "Would anyone pay money for it?" "Can it be used for something else?" (Possible answers: No, it's trash; maybe; yes)

Ask those who said "maybe" and "yes" what kind of litter someone might pay for (Some possible answers: tires, aluminum pop cans, etc.)

Ask, "Have you ever seen someone in your neighborhood picking up cans, bottles, and other things on the street?" "Who were they?" "What did they do with them?" (In some neighborhoods homeless people and others look for aluminum cans, copper pipe, etc. because they have resale value.)

E. Ask, "Have any of you ever picked up someone else's litter on the street and thrown it away in a trash can?" "Why did you do it?" "How did you feel about

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picking up someone else's trash?" (You want to see where the strength of the students' responses lie: in having the neighborhood look cleaner, in not picking up someone's discards because "I didn't do it!")

F. Tell the students that the class is going outdoors for a litter-walk to see what kind of litter you find. The class will bring it back to the classroom in bags, separate the waste from the recyclables, and analyze them.

If you prefer not to do the litter-walk, then show the children the pile of litter you personally collected. Have them discuss it per the questions in Items G-1 and G-6-8, below.

Before going on the litter-walk or reviewing the items in your bag of litter, distribute and review with students the "Litter and What To Do with It" handout.

G. Give the students ground rules for the litter-walk:

1. Wear plastic gloves (or plastic baggies) when handling the litter

2. If you are not sure what something is, ask your teacher or other adult with your class before touching it.

3. If you wish, make a list of things you do not want the children to pick up: e.g., cigarette butts, broken glass, and syringes. You might tell them that if they find items on this list that they should ask the teacher or the aide to pick them up and put them in the bag or in the trash.

   **NOTE: Syringes are extremely dangerous and can be the source of deadly disease. Adults shouldn't touch them directly: use tongs or forceps to pick them up to avoid any contact with your skin. Place the item in a hard, covered container. Call the Health Department to determine a safe disposal site.**

4. Instruct the children to stay in small groups or litter-collector teams

H. Once you have collected the material, ask the students the following:

1. What did you find most -- paper? Cans? Glass? Plastic bags? Newspapers?

Where should each kind of litter go? Recycling container or waste can? Remind them to look at their handout, "Litter and What To Do with It"

2. How did the schoolyard/neighborhood lot look after you finished?

3. How do you feel about the work you did?

4. Would you pick up litter if you were alone or with your friends? Why? Why not? (Reinforce the safety issues of avoiding glass, syringes, and other potentially harmful items.)

5. Why did I want you to wear plastic gloves? If you don't have gloves on, what should you do if you pick up litter on your own? (Keep your hands out of your mouth, don't touch food; wash hands thoroughly as soon as possible.)

6. Should you pick up a piece of litter if you don't know what it is? (No, it may be harmful. You should ask an adult to help you decide what to do with it.) Should you ever touch a syringe? (No. Call an adult for help.)

7. To be safe, what kind of litter should students concentrate on picking up? (Pop cans; newspapers; some food wrapping, such as gum wrappers, chip bags; plastic 1-2 liter pop bottles; not glass bottles, since they may fall with them. If an adult is with them, however, they might ask permission to pick up glass bottles if there is a trash receptacle nearby.)

   Some things might be recyclable only if they are not too soiled or dirty: If newspaper is muddy, it should be put in a waste container. Some soiled things could be rinsed off, such as cans.

8. You may wish to repeat the pick-up over several days to discover what types of materials are being regularly discarded. Ask students where they come from, who puts them there, and what can be done to discourage littering. Experiment with placing waste containers (call the City or ask the school custodian, if the site is on school property) in the areas.

## FURTHER STUDY:

A. Ask your students to think about this idea: Does the kind of litter that is found tell them something about the neighborhood? How could that be so? For example, ask the children to imagine that someone in the neighborhood has an aunt who is visiting. While out for a walk, she finds several pieces of litter along the sidewalk. What do they mean? (Now, show students several pieces of litter you have chosen in advance: a few school papers from a student's notebook; packages from McDonald's -- wrappers, cups, bags; some movie ticket stubs.)

Tell them that the next day she goes for another walk and finds these things (pull from your bag a flyer about an open house for parents, a McDLT box, and a page from the newspaper's movie section with some names of movies circled).

After students have examined the evidence, ask them:

1. What does this litter tell you about the neighborhood? (Possible answers: "People don't care," "There's a school nearby," "Kids going to the school go to a movie theater -- maybe it's nearby," etc.)

2. Which of the materials can be recycled? Put in the waste can? (This depends on what you have chosen: pages from a school notebook might go in mixed office paper if there is no crayon, paint, or paste on them; McDonald's cardboard boxes are plastic-coated and therefore cannot be recycled, but their bags can be recycled with paperboard and cardboard; card-stock movie ticket stubs can be recycled with cardboard, etc.)

B. Contact two community resources for classroom materials about litter prevention and control. For example:

In Cleveland, Ohio, call the Cuyahoga County Planning Commission's Litter Prevention Coordinator, Joan Steidl, 216/443-3700, or write to her at 323 Lakeside Avenue, Suite 400, Cleveland, OH 44113.

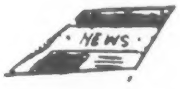
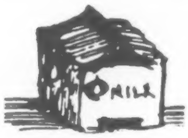
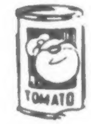
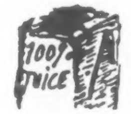
In California, contact Tricia Broddrick, 916/255-2292, or write her at the California Integrated Waste Management Board, 8800 Cal Center Drive, Sacramento, CA 95826 for a listing of your neighborhood litter management agency.

## ACKNOWLEDGEMENTS:

Our thanks to Mary Chadbourne for writing this activity.

## LITTER AND WHAT TO DO WITH IT

**Beside each piece of litter put an "X" under the column that describes the litter. Is it to be RECYCLED or put in the TRASH?**

| LITTER | RECYCLE ♻ | TRASH |
|---|---|---|
| 1. | | |
| 2.  | | |
| 3.  | | |
| 4.  | | |
| 5.  | | |

## TEACHER ANSWER SHEET

## "Litter and What to Do with It"

1. Recycle - No. 2 plastic 2-liter pop bottle

2. Recycle - Newspaper

3. Trash - Gabled milk cartons are made of plastic-coated cardboard and cannot be recycled

4. Recycle - Either an aluminum or steel can

5. Trash - Aseptic juice containers are made of plastic-coated cardboard; they cannot be recycled

For more information on plastics and on what to do with containers and other materials, see the activity, "What Do I Do with It Now?"

# PART III

## EVERYTHING IS CONNECTED

- *Other Environmental Issues*

# COUNTING THE COCONUTS

**Subjects:** Mathematics, environmental science, social science, history, health

**Format:** One class period; may be extended to individual or team assignments

**OBJECTIVE:** To teach students about the impact of human populations on the world that supports them.

**METHOD:** Students analyze a hypothetical case history as a way of understanding how population affects resource availability.

**BACKGROUND:** An inventory of our nation's diverse environmental problems includes bulging landfills, polluted rivers, smog-filled air, and deforestation. Yet, each of these issues is not simply a concern in itself. Each is also the symptom of a larger problem: population growth. The overwhelming numbers of our species have resulted in a slew of environmental problems that threaten our very existence.

Along with our prodigious growth in numbers, we have also exhibited a voracious appetite. The environmental impact of our population is magnified many times by our increasing proficiency at exploiting the earth's resources. Perhaps the most significant example is our ability to turn fossilized plant matter into powerful bursts of energy. Through this process of burning fossil fuels, we unleash millions of years of accumulated sunlight in one stroke. This technology has fueled a dizzying rise in the standard of living for many, particularly those living in developed countries. Yet, convenience and luxury have a price, not only in dollars but also in the long-term health of the world that sustains us.

In his "Essay on the Principle of Population," the nineteenth-century British economist Thomas Malthus investigated this question. Does the natural world exert a natural limitation on the size to which human populations can grow? Malthus

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concluded that it does and hypothesized that this limit would be reached sooner than anticipated. In his essay, Malthus theorized that human populations unchecked by disease, war, or natural disasters will grow geometrically (exponentially), while food supplies will only grow arithmetically.* He concluded that human populations would eventually outstrip their food supplies and be reduced by famine.

## MATERIALS: Both items below are included at the end of the activity:

- Handout/overhead sheet, "World Population Growth Since the Agricultural Revolution"
- Handout/overhead sheet, "World Population Growth of *Homo Sapiens*"
- Handout, "Population Worksheet"

## PROCEDURE:

PART I: Ask students to imagine the following scenario:

Students are on an island surrounded by water as far as the eye can see. The only source of food on the island is a grove of coconut palm trees. Because of soil and moisture conditions, these palms will only grow in the area surrounding the existing grove.

One bushel of husked coconuts is enough to feed a single person for an entire year. Each year, the population of the island increases exponentially.* If the population originally consisted of two people, by the next year it will have grown to four ($2^2$) people. The following year it will expand to eight ($2^3$) people. By the fourth year, the population will have reached sixteen ($2^4$).

Each year, the ability of this population to feed itself increases arithmetically,* due to improvements in harvesting techniques. This means that if the island residents gather ten bushels of coconuts in the first year, the next year they will harvest 20, or 10 plus 10 bushels. The third year they will collect 30, or 10 plus 10 plus 10 bushels, and the fourth year, 40, or 10 plus 10 plus 10 plus 10 bushels. Ask students to calculate the number of inhabitants on the island and the number of bushels of coconuts that they cultivate over time, starting in Year 1 with two people and ten bushels of coconuts and ending in Year 10. (See "Population worksheet at the end of this activity.)

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* In an exponential (or geometric) growth sequence, each succeeding number is computed by multiplying the previous number by a base number. For example, if you started with a base number of 3, the next term would be 3 x 3, or 9. The third term would be 9 x 3, or 27. The fourth term would be 27 x 3, or 81, and so on. In contrast, an arithmetic growth sequence is computed by adding a constant number to the previous term. For example, if you started at 2 and used 5 as your constant number, the numerical sequence in an arithmetic sequence would be: 2, 7, 12, 17, and so on.

Ask students to graph the number of inhabitants over time; then, on the same graph, plot the bushels of coconuts over time.

PART II: Now ask students to imagine that this island is the earth.

Show them the chart and the graph of human population growth. Explain to them that while we are able to count our numbers, we don't know exactly when our population will exceed its ability to feed itself on a global level. We **do** know that our population will outstrip the world's food supply at some point if it continues to expand at its present rate.

Unlike the island, we have found ways to expand temporarily the food supply beyond its natural constraints. In large part, such expansion has been facilitated by fossil fuels. The mechanized farm implements, fertilizers, and irrigation that have boosted crop yields all require substantial inputs of energy, often referred to as "support energy." This support energy comes from non-renewable sources. When it runs out, the party is over.

In addition, fossil fuels have permitted a style of agriculture that exhausts the land beyond its means to regenerate itself. In his essay entitled "The Land Ethic," Aldo Leopold wrote that "the marvelous advances in [agricultural] technique made during the recent decades are improvements in the pump, rather than the well. Acre for acre, they have barely sufficed to offset the sinking level of fertility." Intense cultivation often causes soil erosion and nutrient depletion, resulting in a short-term increase in crop yields followed by a long-term decline.

# DISCUSSION/QUESTIONS:

A. Ask the students whether the population on the island will ever outstrip the available food supply? If so, in what year? (Yes, in year 6.)

B. Ask students to calculate the growth level that enables the largest number of people to survive on the island from year to year. This number is referred to as the **carrying capacity** of the island. (Since the food supply increases arithmetically, the population must do likewise, or else it will eventually outstrip the food supply.)

C. What are the various assumptions made in the island scenario? ( For example, the assumption that coconuts are the only source of food; that one bushel of coconuts is enough to feed one person for a year; that the population increases exponentially, while the food supply increases arithmetically; that island inhabitants cannot move to a new food source.)

D. What other factors besides food limit the size to which a population can grow? (e.g., living space, fuel, building materials, etc.)

E. In his article entitled "The Growing Human Population," Nathan Keyfitz argues that "To wait for natural constraints to intervene to limit population size is to accept famine, low living standards, unemployment, political instability and ecological destruction."

Ask students what practices human populations can establish that would help to prevent the intervention of these natural constraints? (For example, some countries have placed limits on family size.)

F. What social needs or cultural beliefs might conflict with these practices? (For example, in third-world countries, children are needed to help work the land, the more the better; some religions are opposed to explicit sex education, birth control, and/or abortion, etc.)

G. Ask students to consider the following statement: "If we're not keenly aware of the choices we're making, we're not likely to work for better ones."

What can be gained from learning the impact of human populations on the natural environment?

H. Are there organisms you know of that have outstripped the resources in their local area?

What conditions would make it possible for such outstripping to occur on a global level?

I. Explain to your students that the island scenario described in the "Procedure" section is an example of modeling. What is a **mathematical model**? (A mathematical model is a numerical approximation of a complex system used to anticipate future outcomes.) Ask them the following questions:

How does it work? (Modelers identify the different factors that impact a system, determine a means for approximating these factors mathematically, and then enter different sets of input data to test the model.)

What are the benefits of modeling? (It can serve as a useful tool in understanding complex relationships. In addition, an accurate and effective model can predict the long-term impact of certain conditions on the system.) What are its drawbacks? (Models require a considerable base of knowledge before they can be constructed. Modelers rarely understand all the factors that impact a system and thus develop models that oversimplify this system. As a result, models contain a built-in degree of inaccuracy that hinders their ability to provide accurate predictions.)

J. What are the factors that can lead to a change in the population of a given country? (Epidemics, immigration and emigration, improved health care to offset infant mortality and early death, etc.)

K. What might be a mathematical way to represent the change in population of a given country? (e.g., change in population = births - deaths + immigrants - emigrants)

**FURTHER STUDY:** Ask students to research examples of sustainability around the world, i.e., communities that have succeeded in living within the natural constraints of the land.

## SOURCES:

Blaxter, Sir Kenneth. *People, Food and Resources*. Cambridge: Cambridge University Press 1986.

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____. *The Population Explosion*. New York: Simon and Schuster, 1990.

Ferrell, J. E. "Still Trying to Feed the World." *The Plain Dealer*, December 12, 1991, p. 4-C.

Keyfitz, Nathan. "The Growing Human Population." *Scientific American*, Sept. 1989) pp.119-126.

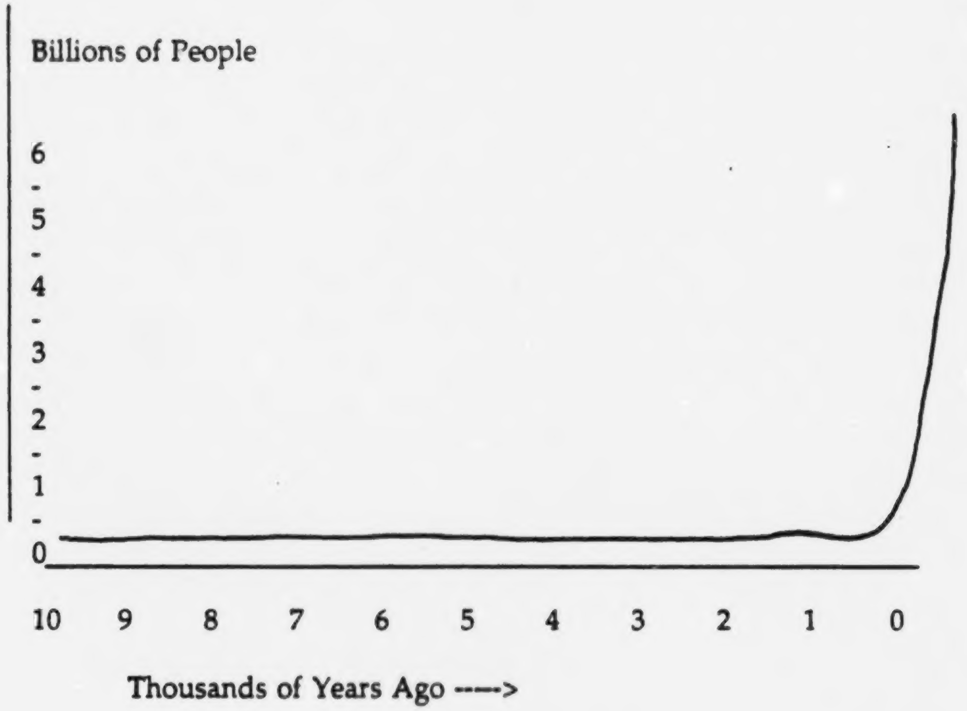
Wessells, Norman K. and Janet L. Hopson. *Biology*. New York: Random House, 1988.

## ACKNOWLEDGEMENTS:

Our thanks to Ben Hitchings for writing this activity.

# HANDOUT/OVERHEAD SHEET

World Population Growth Since the Agricultural Revolution



**Source:** Wessells, Norman and Janet L. Hopson. *Biology*. New York: Random House, 1988.

## HANDOUT/OVERHEAD SHEET

World Population Growth of *Homo Sapiens*

| Billions of Years | Time Taken to Reach | Year Attained |
|---|---|---|
| 1 billion | 35,000 years | About 1850 A.D. |
| 2 billion | About 80 years | 1930 |
| 3 billion | 30 years | 1960 |
| 4 billion | 15 years | 1975 |
| 5 billion | 12 years | 1987 |
| **PROJECTION:** | | |
| 6 billion | 11 years | 1998 |

Source: Wessells, Norman and Janet L. Hopson. *Biology*. New York: Random House, 1988.

# POPULATION WORKSHEET

Under the "Population" column and the "Bushels of Coconuts" column, finish writing in the numbers. "Population" grows exponentially, while "Bushels of Coconuts" grow arithmetically.

| YEAR # | POPULATION | BUSHELS OF COCONUTS |
|---|---|---|
| #1 | 2 | 10 |
| #2 | 4 | 20 |
| #3 | 8 | 30 |
| #4 | | |
| #5 | | |
| #6 | | |
| #7 | | |
| #8 | | |
| #9 | | |
| #10 | | |

# YUCKY, ICKY, SCARY . . . OR WHAT? ENVIRONMENTAL AWARENESS AND ATTITUDES

**Subjects:** Social studies, mathematics, language arts, science

**Format:** Flexible -- a single or multiple class periods; can include activities and field exercises in the school yard or adjacent neighborhod

PICKL PIG'S
SNAILS · ESCAR

**OBJECTIVE:** Students will be introduced to the following ideas: (1) Earth is a home that students share in common with everything else on the planet; (2) "different" from what we know (people, animals, rocks, food, etc.) doesn't mean "bad," "ugly," or "dangerous"; (3) every living and non-living thing on Earth plays a role, "has a job" to do in the environment; (4) the more we learn about the rest of our Earth "housemates," the better we can care for our environment, our home.

**METHOD:** The teacher will lead this environmental sensitizing/awareness activity by discussion; by displaying in class some of the familiar Earth "housemates" about which children may have already acquired strong feelings; and, if the teacher chooses, by taking the children on a walk around the school grounds or the neighborhood to look at other parts of our Earth-home.

**BACKGROUND:** Children learn confidence and fear, respect and disrespect, concern and indifference, kindness and violence, attraction and revulsion toward others and other things both from those around them -- parents, brothers and sisters, classmates, television and movie characters -- and from their own first-hand experience.

Our focus in this activity is on exploring and revisiting some negative attitudes by providing children with facts about things in their environment that they fear or otherwise hold at emotional arm's length. Sometimes they are deliberately taught these reactions by others in hopes of preventing them from coming to harm. No responsible adult wants a child to try to pet a wild rat hiding under a stairwell; nor would a parent wish its child to eat a piece of rancid meat.

But how parents (and care-givers in particular) tell children about these possible dangers may do more than just stop *that* behavior *this* time. It may set up a life-long reaction toward animals that scurry, are furtive; or toward any food that has an aroma and an appearance that differs from what is very familiar to the child. How a child reacts to a stray dog with mange; a rotting piece of food in the refrigerator; a worm on the sidewalk after a heavy rain; a garter snake slithering through the grass beside a building; or any unfamiliar people, events, and objects will depend upon attitudes that the child has been taught.

Both learned attitudes and fear of the unfamiliar can be important to survival. But they also can foster prejudice and ignorance; they prevent the child from "reconsidering," looking at new information. Cutting off thought and inquiry harms children; it prevents them from examining life through their own eyes, of evaluating their own experiences. Obviously, some rules are necessary for kids to grow up safely, but children also need to know "why," -- a question that many learn not to ask exasperated parents, other care-givers, or even teachers.

This activity will help you to explore students' "attitudes" toward things in their world -- in this case, animals and foods. One's attitude toward the rest of the world holds great importance for the future of the environment. Children who can reconsider, adjust, look at familiar things in a new light are children who will be able to understand that "everything is connected to everything else." Kids who understand this will be able to revisit their fears, re-evaluate their belief that the only good spider is a dead one, or that bats "will suck your blood" so they should be killed.

Adults also hold "received" attitudes, those based on someone else's experience, not their own, and attitudes based on very little direct experience. The challenge for the teacher is to overcome these and serve as a catalyst to spark children to confront fears and prejudices, to reevaluate their attitudes in light of new information and experience. Helping children to do so will widen their horizons about what "resources" are: they do include moldy bread and rotten bananas. Snakes, worms, bees, mice, ants, and spiders have their place on Earth, along with humans, and it is important to respect their lives as well as our own.

NOTE: Elementary school teachers have a wonderful opportunity to introduce and "sensitize" children -- i.e., make them aware of and receptive to all manner of animals, plants, minerals, and other phenomena. Bring living things into the class and teach children to care for them. Making plants and animals part of the classroom will help children to accept and enjoy the natural life around them, which they may otherwise rarely, if ever, experience.

Whether you are a generalist or a scientist (by training or preference) is not important: curiosity, respect, and care toward living and non-living things are values you can help students embrace by having a lively, ever-changing classroom environment.

**MATERIALS:** This is a list of **suggested** items. You needn't have all of them. But, if at all possible, use the actual items and animals. (You can select other animals besides snakes, spiders, worms, flies, or mosquitoes, but these are familiar to most children and some often elicit strong reactions -- fear, curiosity, revulsion, delight, disgust.) If you don't have access to them, see if you can borrow some from other teachers in your school building or system. A call to your building or district's science coordinator should help you track down likely sources.

The local zoo may be able to provide live animals or specimens or advise you on where to find them. If the season of the year limits your access to insects, you can omit them and use only snakes, mice, etc. Or, you may focus the activity on foods only. You can use pictures if you can't provide the real thing, but the ideal is to have the actual object so that children's responses will be immediate and genuine, not imagined:

- A green banana, a ripe banana and a very rotten, decomposing one; other green-to-ripe-to-rotten fruit & veggies can be used
- A few worms in soil
- Ants, spiders, flies, fireflies, mosquitoes, or fruitflies in jars; either place plastic wrap over the opening and poke a few air holes and seal the wrap with a rubber band or punch air holes in the lid
- A piece of blue cheese (roquefort, gorgonzola), a piece of very moldy cheese, a jar of Cheese Whiz
- A clean, empty soup can and a rusty one
- Snake in a large jar or enclosed terrarium
- Mouse in a terrarium

- Frog in a terrarium
- Finch, parakeet, or canary
- Bird or mouse nest that includes bits of fabric, paper or other found objects into its design
- Unusual foods (suggestions): Ginger root, pickled pigs feet, bamboo shoots, mushrooms, snails (escargot)[1], Fish eggs (caviar)[1]
- Toothpicks and/or popsicle sticks, a cutting board, and a knife to provide taste-test samples
- Spoiled food from your refrigerator -- something without milk products or meat in it (therefore compostable)
- A number of books you have gotten from the library that feature the animals you have brought to class or the foods you are featuring.

**PRE-ACTIVITY QUESTIONS:** Ask your students the following questions:

## A. ANIMALS

1. What are your favorite animals? Write the names on the board under the word "LIKE." Ask children why they like these animals, and write the reasons down beside the name of the animal. (Possible answers, " Dogs are friendly," "monkeys are fun to watch," etc.)
2. What animals don't you like? Why? Write the list down under the words "DON'T LIKE." Whatever the reasons for the children's dislikes, record these as well (e.g., "don't like dogs or cats because they bite or scratch") beside the animal's name.

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[1] These are expensive items -- perhaps $4-5 for the snails, as much for a very small jar of caviar. We certainly don't recommend them for your lesson unless you love to eat them! You may be able to think of equally foreign looking but less expensive foods that some children might balk at eating (tripe, capers, pickled pigs' feet, etc.).

### B. FOODS

What are your favorite foods? (Continue asking and recording the same questions about food as you asked about animals in A & B, above.)

## PROCEDURE:

### A. ANIMALS

1. INTRODUCTION: Ask the students how they feel about snakes, mice, bees, ants, worms (whatever animals you have brought in). Ask them why they feel this way. Record these names and reasons on the board. (Tell the children that you have brought in books and pictures about many animals and that they are welcome to look at them after the activity is over.)

   Are these animals ever helpful? How? (Some possible answers: snakes eat insects; spiders catch mosquitoes in their webs, bees make honey and help pollinate plants; mice and ants eat crumbs of food around the house; bats eat mosquitos and other insects, etc.)

   Some animals do indeed carry diseases, however; so they can be both helpful and harmful: raccoons and dogs can carry rabies; flies and mosquitos carry bacteria and viruses, and so do we.

2. CHILDREN'S FEARS & FEELINGS: The goal is to collect answers, respect students' reasons, and show that students can have very different reasons for liking or disliking something.

   Depending on the animals you have brought in, ask questions that touch on misconceptions about the animals or a child's particular fear. Probing what the child thinks about an animal will help determine whether the response is based on first-hand experience (being startled by a mouse -- its quickness, its long tail) or something someone has told the child -- it's dirty, it will bite or sting, it carries germs that will make you ill). A child who is allergic to bee stings has a very serious reason for avoiding bees, since the allergy can be life-threatening. A general fear of unfamiliar things is a response that some children will have, while others will be more curious than anything. These differences in children's attitudes should be respected as individual differences and not allowed to become a source of derision (e.g., the child who is genuinely afraid of mice).

Overall, the goal is to show respect for children's fears or phobias, while exposing them to a controlled, safe experience in the classroom with animals they fear or dislike. Be sure to reinforce the idea that one child's experience (fun with an animal) is just as valid as another's (bitten and had to have stitches).

3. ARE SOME ANIMALS BAD? In the course of your discussion with children, establish the idea that no animal is "bad." Like all animals on earth -- including humans -- an animal has its place in the ecosystem; it is one of our Earth housemates. When an animal gets too close to or moves into our space, that can cause problems (e.g., mice or rats, flies, mosquitos, etc.).

   Emphasize that some animals that are sick or hurt or are protecting their babies can be dangerous, although they might normally ignore you or be friendly. (Pet dogs, cats, etc.) They may bite or scratch to protect themselves if they feel frightened or to drive humans and other animals away if they sense possible harm to their babies.

4. SNAKES & WORMS: Are snakes slimy? Are worms? (Snakes are dry skinned, but their shiny scales often make them appear as if they are wet, hence "slimy." Worms secrete a mucous that helps them to glide through soil and decomposing material in the ground.)

   Have any of you ever touched a snake? A worm? (Ask their reactions -- some children may have used worms as fish bait.) Tell children that some snakes are completely harmless, such as the garter snake. But children should never try to pick up a snake unless they are certain that it is harmless, since some do bite and are poisonous. They should not harm a snake unless it is going to hurt them or their friends.

5. MICE: Where do you find mice? Have any of you ever had mice in your house or apartment? What do the mice do? Do any of you keep them as pets at home? Where do mice usually live? (Mice often live outdoors eating grains, nuts, fruit, and other foods, but when the weather turns cold, they come into houses and apartment buildings for shelter.) Why are some people afraid of mice? (They're fast, can surprise you with their sudden appearance. They're "nocturnal," hunting for food at night and therefore make scurrying sounds as they search for food and sometimes chewing through cereal boxes, plastic storage containers, etc. Institute staff had mice that even developed a taste for kiwi fruit!)

6. FROGS & TOADS: Has anyone ever seen a live frog or a toad? Where do they live? Where are their babies born? What do they eat? (Set up a terrarium for frogs or salamanders in your classroom.)

## B. FOODS

1. Ask the students how they feel about the food you have brought in. Show them one sample at a time: the green banana, the ripe banana, and the rotting banana. What's the difference? Do they like bananas? How do they feel about the rotting banana? What should be done with it? Record their reactions. In this case, ask if the rotting banana is good for anything. Do any of them have gardens? What would happen if we buried the banana in the garden? Probe to see if the students are familiar with composting, with bacteria and worms decomposing food and yielding "humus," a soil enrichener.

   (As a variation, you could also have an unripe [green] apple and a "Granny Smith" apple, which is green when ripe. Ask the students whether either apple should be eaten? Why? Why not? Possible answers: "green apples give you a stomach ache," "green apples taste sour," etc.)

2. If you are using several cheeses (a rotten one, a blue cheese, and Cheese Whiz), the point is to teach children that not all apparently "moldy" food is bad: some mold is cultivated to add flavor to some foods.

   You might ask the children which of the cheeses they would be willing to eat. Some may have had blue cheese. If so, ask them if they would like to sample this one. Would others? Ask the students why they feel as they do about the cheese. Do they feel the same way about Cheese Whiz? Why? Why not? Do any of them see the connection between familiar foods and acceptance of those foods versus unfamiliar foods and rejection of those foods?

3. Do they know of any other foods where bacteria and mold are important to flavor? (e.g., sides of beef are allowed to age in lockers, with mold and bacteria building up on the outside and tenderizing and enhancing the flavor of the inner meat through the various chemicals produced as they grow on it and penetrate it. After several months, the spoiled outer layer is cut off, leaving a highly prized, naturally tenderized and uniquely flavored meat. Yogurt depends on bacteria for its flavor and texture.)

4. The purpose of exposing children to unusual foods is to learn their attitudes toward the unfamiliar, things that are strange in appearance. For unusual foods you might bring in ginger root, snails, bamboo shoots, mushrooms [many different shapes and flavors; some are poisonous and you may wish to discuss those as well], pickled pigs' feet, snails, caviar, etc. Display them so that children can look at them, detect any odor, etc. Do they know what each one is? Have they eaten any of them before? Would any of them like to try a taste? Why? Why not?

Some children may be willing to try the food, although they've never had it. List their reasons along with the reasons of those who wouldn't go near the food. Allow them to sample small tastes with toothpicks or popsicle sticks.

After this discussion and sampling, note any cultural and ethnic backgrounds you know about these foods. Explain where each one comes from, that it is considered a wonderful treat by those who like its taste.

Ask them if they eat anything now that they didn't like when they were younger. What is it? Have they tried any new foods lately that they liked? What were they? Didn't like? What were they?

Show the students your moldy leftovers from the refrigerator. How do they feel about them? Record their answers on the board. Ask them if this moldy food is good for anything? If so, what? (Possible answers: "give it to the dog," "bury it in the garden," "scare a brother or sister with it," etc.) Explain that this food is spoiled. Molds and perhaps bacteria are growing in it.

Explain that they make the food taste unpleasant, but that this food of yours is still very good for something -- you can compost it (bury it in your yard -- or garden, or with flowers and plants -- where the worms in the ground and other organisms in the soil will break it down and eventually make humus, a rich addition to soil that helps plants to grow). If you have brought in worms in soil, add some small amounts of food to the container for the worms to eat. These composters make very rich soil from such old food. This new soil helps plants to grow.

Complete the idea that it is best not to let food become moldy or rotten, but if it does, it is still valuable as a resource: it can feed other animals (worms, bacteria, etc.) and that benefits us with richer soil. Explain that the worst thing that could happen is to throw the food away in the trash: it then goes to the landfill and its nutrients are lost to all of us -- humans, worms, bacteria in the soil -- forever.

See the activity on worms and composting called "Striking It Rich with Classroom Composting."

**DISCUSSION/QUESTIONS:** Ask your students the following questions:

A. We've all said that we did like some things and that we didn't like some things today. What were the reasons for not liking things? (Possible answers: "Afraid," "ugly," "gross," "smelly," "disgusting," etc.)

B. What do you see in your neighborhood that you think is good for the Earth? Bad for it? Why?

C. What can you do to help other people learn to take better care of the Earth?

1. Feed the worms: they convert old fruit and vegetable wastes into rich soil.
2. Don't harm any animal unless it is going to hurt you or your friends.
3. Pick up recyclable litter and recycle it.

These are just examples. Let students develop these. Then, plan how to make them work. Take one per week as an emphasis for the class. Assign teams of students to put their **findings** into **actions**. Establish a year-long plan to do something about making the classroom, school, and the community environmentally better.

## VARIATIONS:

A. If you have the facilities, arrange with the cafeteria staff to make some foods that use bacteria, yeasts, etc: conventional bread, sourdough bread, yogurt. (A simple recipe for yogurt appears at the end of this activity; an oven is preheated to 275°; the oven is then turned off and the yogurt mixture placed in the oven to "work" for 8 hours.)

B. With the help of parent volunteers or through the PTA, arrange a class picnic (or even a school potluck) that encourages students to bring in a dish that expresses their ethnic heritage or is otherwise a family tradition. Emphasize the value of

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sharing unusual dishes so that students can benefit from the diversity of what other people consider a delicious treat.

C. Set up a classroom worm composting bin (See activities titled "Striking It Rich with Classroom Composting" for simple and in-depth ways, respectively, to do this) and compost student food waste in it so that students see first-hand how worms and other decomposers make humus, a rich addition to soil.

D. Commit yourself to introducing your students to one new plant, animal, food, custom, idea a week. Your choices should foster the concept that "different" is fascinating, not fearful, disgusting, or to be avoided.

E. Set up terraria and cages in the classroom that feature mice, gerbils, frogs, snakes -- animals that are compatible with one another and which children can observe and care for. Purchase *Animals in the Classroom: Selection, Care, and Observations*, David C. Kramer, Addison Wesley, Menlo Park, CA, 1989, 234 pages.

This excellent publication discusses the planning of a live animal project and presents various cages, equipment, and appropriate environments for the animals. The invertebrates include earthworms, snails, crickets, fruit flies, spiders, crayfish, and hermit crabs; the vertebrates described are several types of fish, amphibians, reptiles, birds, and mammals.

F. Zoos, metroparks, and museums of natural history will have guest speakers with live animals, as well as teacher resource centers for establishing in-class live-animal habitats.

G. Contact other teachers who have already established cages, aquaria, or terraria in their classrooms or students' homes. Invite their students to present to your students the activities they conduct.

H. These activities lead easily into discussion of endangered species. We recommend *The Endangered Species Handbook* , 1983, 245 pages, by The Animal Welfare Institution, P.O. Box 3650 , Washington, D.C. 20007; telephone 202/337-2333 Encourage children to observe the animals by giving them assignments (art assignments to draw them in various positions, responsibility for feeding them, etc.).

# FURTHER STUDY:

A. Assign your students to bring in examples of unusual animals, foods, and other topics which you assign. (Examples might include bringing in pictures of animals such as the platypus.)

B. Set up a "fascinating facts" bulletin board for students' contributions. (Make sure you set some parameters; otherwise, you may find yourself inundated with trick photographs and stories from the tabloids!)

# ACKNOWLEDGEMENTS:

Our thanks to Mary Chadbourne for writing this activity.

## OVEN YOGURT*

A. 3 cups dried skim milk
5 cups water
1 can evaporated milk

**Mix the above ingredients well.**

B. 1 tablespoon unflavored gelatin, softened
1/4 cup cold water
3/4 cup boiling water added to dissolve gelatin
1 teaspoon sugar

**Cool the above 4 ingredients and then add them to the milk mixture, "A."**

C. 3 tablespoons of unflavored yogurt (e.g., Dannon) as starter

**Stir in the starter yogurt with the mixture of "A" and "B."**

D. Put in a pre-heated (to 275°) oven. Turn oven off and leave the yogurt mixture in it for 8 hours to "work." Then remove and refrigerate.

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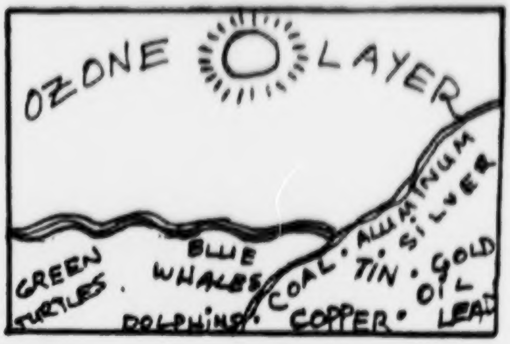
* This is a recipe given to me some years ago by classmate Carol Donley. (M. M. Chadbourne)

# EARTH'S FINITE RESOURCES

**Subjects:** Geography, science, environmental science, social studies, language arts, mathematics

**Format:** One class period



**OBJECTIVE:** Students will (1) experience the scarcity of finite world resources through the use of a simulation; (2) learn the limits of resource recovery without waste reduction, reuse, and recycling; (3) discuss how global politics and population are factors in the management of limited resources; (4) be introduced to the importance of resource management on a global level; and (5) learn the importance of renewable resources compared to nonrenewable (finite) resources.

**METHOD:** The students will literally search the classroom for variously colored beads that represent finite resources. Their success will be discussed in light of the actual global reserve base (1988 figures). Another variation of the simulation involves a second search, only this time students are allied with countries that have sometimes conflicting goals and interests. The variables of politics, population growth, economic costs of extracting dwindling reserves, and other factors will then be discussed.

**BACKGROUND:** The earth contains a finite supply of mineral resources. Wasting resources - using them only once and not recycling - shortens the time these resources will be available. As countries become more industrialized, affluent, and developed, they consume and waste more finite resources. Concepts that students will encounter in this activity include "entropy,"* (the Second Law of Thermodynamics),

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* *Entropy* is a measure of the chaos or disorder in a system, such as the Universe. The Universe is increasing in entropy, from a more ordered to a disordered, or random, state. The Second Law of Thermodynamics states that the entropy of a "closed system" increases with time and that heat cannot be transferred from a colder body to a hotter body. (Definitions rephrased from *Uvarov, E. B. et al. A Dictionary of Science.* London: Penguin Books, 1973.)

"resource management," "conservation," "stewardship," and "nonrenewable resources" versus "renewable resources" (i.e., finite versus infinite resources).

## MATERIALS:

- Charts titled, "A Look at What's Left," "Depletion Time for Non-renewable Resources," and "Selected Nonrenewable Natural Resources: Their Life Expectancy and Prime Consumers"
- Colored beads and coins in numbers required (see hand-out, "A Look at What's Left")

## PROCEDURE:

A. Version One

1. Select beads of different colors to represent finite resources (see chart at end of the activity for numbers, colors. etc.).
2. Hide beads and coins throughout the classroom and divide students into teams representing countries. (Make sure some of the beads are hidden so well they will not be found immediately.)
3. Give teams timed intervals of two minutes and one minute to explore for resources. (Each team will search for two minutes, examine their findings, and then search again for one minute each and compare their findings with those during the two-minute search.)
4. After exploration, students are to separate and identify the mineral represented by each color of bead or coin (see attached chart).
    - Discuss the greater difficulty in finding resources during the second exploration.
    - Discuss what is required to explore for and obtain resources (among other things, energy).
5. Ask students whether energy is a renewable or nonrenewable resource.

What is happening to world population? What effect will rapid population growth have on the future availability of nonrenewable natural resources?"

Is competition for resources emerging among countries? Think of examples.

6. After exploring, ask students to jumble the "resources" together. Ask them these questions:

   What is this jumble of resources like? (A dump or a landfill)

   What did it take to get these resources into a usable condition in the first place? (Energy, refining/separation)

   What is necessary to keep these resources in the cycle of use? (Separation and recycling)

7. For older students (unless teacher supplies the concepts in advance in simplified form at lower-grade students), ask the following questions:

   What is entropy?

   Why is jumbling resources together and throwing them away an example of entropy?

   What is the Second Law of Thermodynamics? How is wastefulness related to the Second Law?

   What can you do to extend the life of finite resources?

   What are the advantages of extending the life of these resources?

8. Hand out and discuss the charts at the end of the activity: "Depletion Time for Non-renewable Resources," and "Selected Nonrenewable Natural Resources: Their Life Expectancies and Prime Consumers."

   How long are minerals widely used today predicted to last?

   How old will your children or grandchildren be when these resources will, perhaps, be exhausted? What effect will resource depletion have on your life?

B. Version Two

1. Using the chart, "A Look at What's Left," at the end of the activity as a basis for your distribution, hide beads throughout the room, keeping some colors in large groups to represent concentrated ore deposits. Hide some beads very well. Also hide one or two differently colored beads to represent rarer strategic metals, such as chromium and platinum.

2. Divide students into groups representing different countries: two adversaries (such as the United States and Iraq), two small industrialized countries (such as Japan and Sweden), and four developing third world-countries (such as Brazil, India, Zimbabwe, Guinea). The number of countries can be changed, but the number of students per country should reflect relative populations. The idea is to reflect the world's unequal distribution of population and resources.

3. Have students "explore" again and report on the resources that they find as groups. Hold two rounds of searches, if you wish, as in the first version of the activity.

4. After resource holdings by countries have been reported, ask students to consider the implication that some rare strategic minerals are found in countries controlled by governments that may not favor trade with other countries whose political and economic beliefs differ from theirs.

4. Assign students to explore the possibilities of what to do about local and future shortages of resources. Possible solutions include: recycling, conservation, trading and treaties.

5. Assign students to come up with still further versions of the activity to illustrate principles that will affect the world's resource supplies in the future. What variations can they suggest?

6. Consider extending this activity by adding money to buy resources, setting up cooperative ventures between countries, forming resource cartels, etc.

# DISCUSSION/QUESTIONS:

A. Ask the students in what ways the simulations were effective, ineffective. What would they change in order to improve the simulation? How could it be extended to other related topics?

B. Ask students what suggestions they have for more frugal and cooperative management of finite global resources. Even the ozone layer is a global resource, and the United States has contributed a significant amount of damage because of its reliance through the 1970s and 1980s on CFCs (chlorofluorocarbons). What measures could be taken to prevent future losses such as this one?

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## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology for permission to use/adapt this activity from its publication, *A-Way with Waste.*

## Selected Nonrenewable Natural Resources: Their Life Expectancy and Prime Consumers

| Resource | A. 1988 World Estimates of Reserves | B. Countries/Areas with Highest Reserves | | C. % Resource Imported for US Needs - 1987 | D. Life Expectancy (in yrs) | | E. Amount Recycled Worldwide 1988 |
|---|---|---|---|---|---|---|---|
| | | | | | Static Use at 1976 Level | Use Growing at Projected Rates | |
| Aluminum (in bauxite) | 21,800,000 thousand metric tons | Guinea<br>Australia<br>Brazil | 25%<br>20%<br>12% | 97% | 312 | 63 | No bauxite recycled. In US, 64% of aluminum cans recycled |
| Chromium | 1,030,000 thousand metric tons | Rep of South Africa<br>Russia & breakaway republics | 80%<br>9% | 75% | No data | No data | Chromium contained in purchased stainless steel scrap accounts for 25% of demand |
| Copper | 350,000 thousand metric tons | Chile<br>European/Free Asian markets<br>USA | 24%<br>17%<br>16% | 26% | 63 | 36 | Old scrap: 520,000 tons or 23% of consumption; New scrap: 200,000 tons |
| Gold | 1,416 million troy ounces* | Rep of South Africa<br>European/Free Asian markets<br>Russia & breakaway republics | 53%<br>20%<br>14% | No data | No data | No data | Old scrap: 1.7 million troy oz or 50% of consumption; New scrap: 2.6 million troy oz |
| Iron in Ore | 72 million short tons | Russia & breakaway republics<br>Brazil<br>Australia | 34%<br>15%<br>14% | 22% | 172 | 62 | There is no significant recycling of iron ore. In 1987, iron and steel recycled as scrap totaled 750 million tons.* |
| Lead | 75,000 thousand metric tons | Centrally Planned (Socialist) Economies<br>Australia<br>USA | 26%<br>21%<br>14% | 17% | 172 | 25 | Recovery of lead from scrap batteries: 570,000 tons |
| Ammonium Group Metals | 1,810,000 thousand troy ounces | Rep of South Africa<br>Russia & breakaway republics | 88%<br>10% | 88% | No data | No data | 200,000 oz from nontoll scrap. 1.7 million oz scrap |
| Silver | 9,000 million troy ounces | European/Free Asian markets<br>Canada<br>Mexico | 33%<br>13%<br>13% | 57% | 20 | 17 | Old scrap: 25 million troy oz or 21% of consumption. New scrap: 54 million troy oz |
| Tin | 4,260,000 metric tons | Malaysia<br>Indonesia<br>Brazil | 26%<br>16%<br>15% | 72% | 41 | 31 | Old and new scrap: 15,000 tons |

* A troy ounce equals 1.1 ounces avoirdupois.

Sources: Cols. A,B,C: U.S. Bureau of Mines, *1989 Mines Commodities*; Col. D: *Global 2000 Report*, Col. E: U.S. Bureau of Mines, *1989 Mineral Commodities*; * *Scientific American*, Sept. 1989, Vol. 261, No. 3, p. 148.

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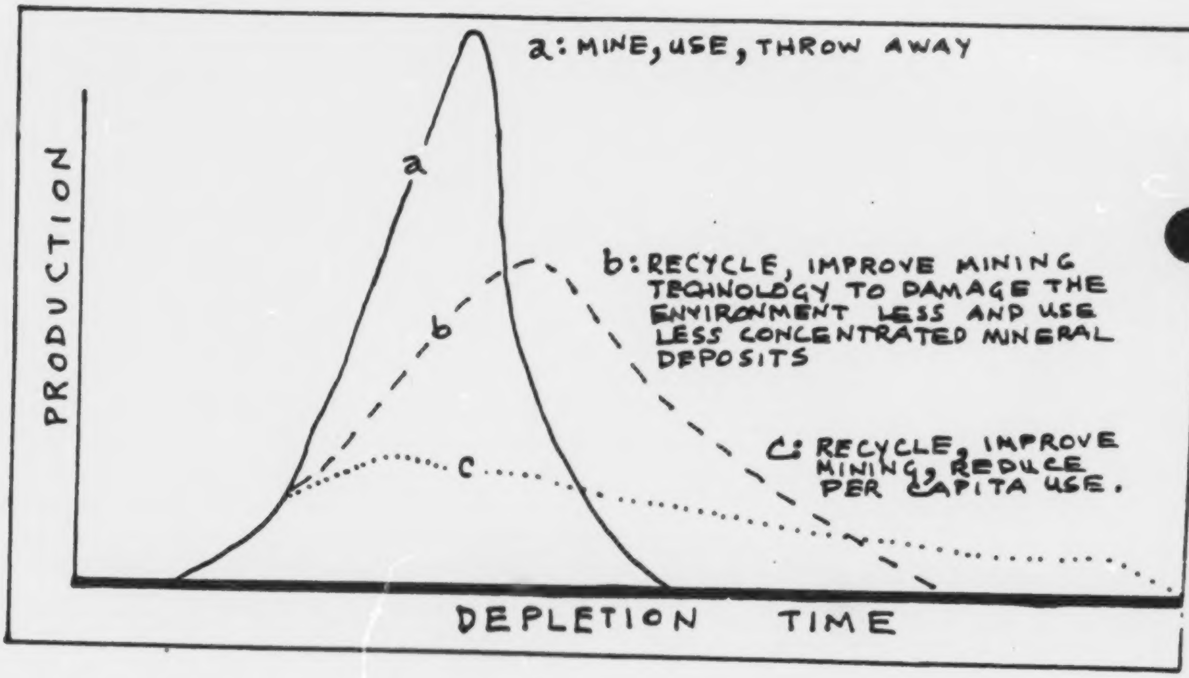
## Depletion Time for Non-renewable Resources



# A LOOK AT WHAT'S LEFT

| Color | # Beads | Finite Resource | 1988 Estimates of Global Reserve Base* |
|---|---|---|---|
| Red | 416 | Iron in ore | 102 billion short tons |
| Blue | 104 | Bauxite | 23.2 billion metric tons |
| Yellow | 1 | Tin | 4.2 million metric tons |
| Silver coin | 1 | Silver | 14 billion troy oz |
| Green | 3 | Copper | 560 million metric tons |
| Orange | 1 | Lead | 125 million metric tons |
| Purple | 28 | Chromium | 6.8 billion troy ounces |
| Coin | 1 | Platinum | 2.1 billion troy oz |
| Black | 20 | Oil | 708 billion barrels** |

* "The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those are currently subeconomic (subeconomic resources)." U.S. Bureau of Mines, *Mineral Commodities Summaries 1989 Summaries*, Washington, D.C.: U.S. Government Printing Office 1989.

** Oil reserves source: Brown, Lester R. and Sandra Postel, "Thresholds of Change," *State of the World 1987*, New York, N.Y.: W.W. Norton & Company, 1987, p. 12.

Metric ton = 2,200 lbs
Short ton = 2,000
Troy ounces x 12 = lbs

NOTE: The number of beads reflects a mineral's relative, estimated total abundance -- not the ease of extraction or potential availability of that mineral. The beads are not distributed in exact percentages to allow for hypothetical and undiscovered resources.

# ROCKIN' RECYCLABLES

**Subjects:** Drama, speech, art, language arts, environmental science

**Format:** One or multiple class periods -- varies with teachers goals and student availability for after-school rehearsal

COMPOST
BUBBA
BEULAH
BITSY
BIGGY
BIX

**OBJECTIVE:** To teach students about the problem of solid waste. In addition, students will learn how to communicate with others artistically.

**METHOD:** Students write, rehearse, and perform their own school play. (This activity is written as if it were for a whole-school production. The activity can be adapted to be a single classroom's activity, with the students of the class performing their play for the rest of the school, lower or upper grades, the PTA, the School Board, the public. It might be used for kicking off your recycling program.)

**BACKGROUND:** A long-standing tradition in the theater marries performance art with important social issues (war profiteering in Arthur Miller's *All My Sons* and George Bernard Shaw's *Major Barbara*; women's equality with men in Henrik Ibsen's *A Doll's House*). Done effectively, a play can be both entertaining and instructive.

We encourage you to challenge the students to think seriously about their intended audience as they begin to plan. Though a "serious" treatment of the subject may be appropriate for older students, it may limit the appeal of the play for others. Encourage students to think about how they can convey their message to the greatest number of people, so that their personal resources -- their energies and efforts in planning, writing, casting, rehearsing, making costumes and props, publicizing, and performing -- can reach many.

Students can begin their planning by discussing the three ecological principles we have used in this manual for organizing the activities. These three may give them ideas for generating an approach for their play:

- Everything ends up somewhere
- We have options and we make choices
- Everything is connected

Other principles they suggest should also be explored as sources of ideas. Above all, the teacher should do everything possible to make this activity fun: it provides an opportunity to involve kids in a team-based activity. And it provides an opportunity to use the talents of everyone in the class -- art, writing, acting ability, musicality (if you choose to have music), overall creativity.

As an aide to getting the creative processes flowing, we have outlined a possible production. Included are a story idea, characters, and some suggestions for costumes and scenes. (See "By the Skins of Our Bananas" at the end of this activity.)

**MATERIALS:** All plays will require costumes, scenery, and props of some kind (unless you want to make some special demands on the audience's imagination!). The exact materials needed for the activity will depend upon the script written by the students. The emphasis should be on good action and dialogue and not on fancy props. Be sure to explain to students that they should be expert "trash masters," using recyclables, existing materials and reusable materials -- not virgin materials, if at all possible -- to maintain the spirit of the play's message and to be good resource managers.

**PROCEDURE:** From concept to performance, the theater project includes a number of different steps. These consist of writing the play, casting the characters, rehearsing the play, making the props, and performing the play.

A. WRITING THE PLAY: Students should begin by deciding what message about recycling they want to convey, who the audience will be, and how many minutes, roughly, the play will last. Once these decisions are made, a writing team can begin sketching out the plot and defining the characters.

With plot and characters known, the students can commence writing stage directions and scripting lines for each character.

Throughout this process, the playwrights should make sure that their script is adaptable to the spoken word. The lines should be easy to say and realistic in terms of who's saying them. One way to make sure that the play works well verbally is to read it out loud at regular intervals throughout the writing process for review and revision. The overall challenge is to craft a play that will be both entertaining and informative.

B. CASTING THE CHARACTERS: Once the script is finished, students can begin casting the characters. This process matches students with characters in the play.

C. REHEARSING THE PLAY: Once the characters have been cast, it is time to begin rehearsing. Under the leadership of the stage director, the cast will begin to work through the play, practicing the lines and rehearsing the accompanying actions.

D. MAKING THE PROPS: At the time the cast is rehearsing, the stage crew should construct the necessary props and scenery. These preparations will culminate in a dress rehearsal in which the cast and the stage crew run through the entire play together.

E. PERFORMING THE PLAY: Once all preparations are complete, the students will perform their play for the rest of the school.

**DISCUSSION/QUESTIONS:** After the performance, ask students the following questions:

A. What were the major problems and solutions that you encountered while writing the play or making the production materials (costumes, props, sets)?

B. What do you think caused these problems? (The play-writing process itself? The subject matter? Learning to work as a team?)

C. How did parents, teachers, students, and others respond to the production? How did this make you feel?

D. What would you do the next time you took on a project like this?

## VARIATIONS:

A. Students may want to turn the play into a musical. (See activity titled "The Ozone Hole Blues" for ideas about songwriting.)

B. Older students can research and develop an environmental drama that addresses other issues besides solid waste.

# ACKNOWLEDGEMENTS:

Our thanks to Ben Hitchings and Mary Chadbourne for writing this activity.

## BY THE SKINS OF OUR BANANAS

A Comedy about a (Possible) Tragedy

CAST OF CHARACTERS:

### The Banana Bunch

Beulah - strong-willed, loud voiced, a leader
Bitsy - shy, sweet, small voiced
Biggy - big but very agile & sweet tempered
Bopper - a rocker, a roller
Blanid - an artist, a dreamer
Bubba - a cut-up, a joke-teller
Bix - musical, mature, easy (has a saxophone, clarinet, flutaphone -- wind instrument of choice, real or imagined; the sounds from it are real or vocalized by Bix to sound like the instrument he plays)

They are all dressed like bananas. Being dressed like a banana is hard work, so part of the charm of each character is dealing with the "costume" while staying in character.

### The Landfill

Approximately 10 students whose roles are unspoken but central to the play. They are dressed in black trashbag tunics and wear plastic mesh potato or onion sacks over their heads, with the face area cut out in a rectangle so that the audience can see their ever shifting expressions. Throughout the play they stand in a semi-circle, absolutely still; they look straight ahead at the audience, never at each other. Their faces bear unhappiness and misery; they are continuously changing, from scowl to scariness, then boredom, anything unpleasant.

### The Compost Heap

Approximately 10 students who are dressed in newspaper tunics and wear hats adorned with flowers, grasses, wheat, leaves, and other natural materials. Throughout the play they stand in a semi-circle and sway gently, their faces full of happiness and pleasure, their expressions continuously changing as they look at each other and at the audience, one bright, content face after another.

**The Everybody Family**

Everymom
Everydad
Everybrother
Everysister

They are dressed in street clothes. They begin as environmentally disrespectful, irresponsible waste-generators and, in the course of the play, grow to become responsible stewards of Earth's resources, beginning with banana skins.

**The Recycling Angel**

Male or female, the Recycling Angel is dressed in recyclables from head to feet. (The challenge to props and costumes is to fashion a body suit and wings that will be both hilarious and instructive: as a suggestion, each wing tip could have a 6-pack of empty aluminum cans, for example, joined by string by their pop-tops, and hanging from a spring attached to each wing tip so that the cans sway and clank when the RA walks, leaps, gestures.) The angel is patient and loving, but firm about getting the Everybodies to do their part.

**PLOT:** The Bananas all want their skins to go to a compost heap, not the landfill. They know that their skin will become part of some wonderful new plant someday. But in the landfill, nothing good will come of them. They'll just sit there and sit there for a million years, uselessly. Because the Everybody Family is not enlightened about recycling, composting or other resource-wise choices, they throw everything in the trash and it is landfilled.

The Banana Bunch decide to call upon the Recycling Angel to help educate the Everybody Family about the virtues of recycling and composting and the vices of landfilling.

In the end, the Everybodies -- young and old -- see the light and begin to run an environmentally responsible household. One by one the banana skins jump gleefully into the compost pile. Immediately afterward, a bright flower, a tree, etc. grows up out of the pile.

All is well. The Bananas are together in the compost and the Everybodies are model recyclers and waste reducers. The Recycling Angel flits happily through the audience passing out instructions on how to compost, recycle, etc.

SCENE 1:

Takes place on a table where the Banana Bunch all sit "bunched" together, apparently joined at their heads to a common stem, then separating as each disengages to get up and present his or her perspective about wanting his/her banana skin to go to the compost heap and not the landfill after one of the Everybodies uses them on breakfast cereal.

SCENE 2:

Takes place in the Everybody Family's house. All over the floor are pieces of "trash" -- paper plates, aseptic juice boxes, styrofoam egg cartons -- very few recyclables. This is clearly a household waiting for deliverance by the Recycling Angel.

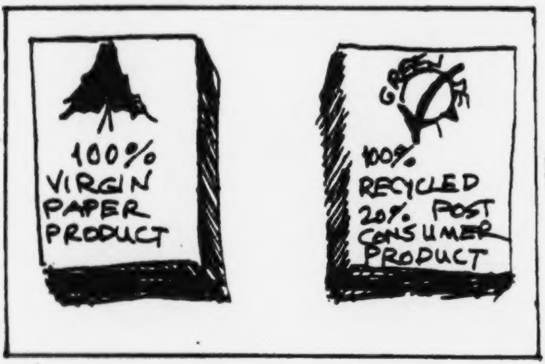
SCENE 3:

The semicircle of the landfill and the semicircle of the compost heap are the two central images on stage. It is here that the play's main conflict and action take place.

# LIFECYCLE ANALYSIS

**Subjects:** English, Speech, environmental science, social studies, economics, mathematics, home economics

**Format:** Individual student or team assignment; single class period or extended research with reporting


100% VIRGIN PAPER PRODUCT
GREEN
100% RECYCLED 20% POST CONSUMER PRODUCT

**OBJECTIVE:** To have students examine the different activities that go into the making and disposal of a product in order to assess its environmental impact.

**METHOD:** Students research and develop criteria for rating the environmental impact of different products and then test several items to determine their comparative rating value.

**BACKGROUND:** In the wake of Earth Day 1990, two nonprofit organizations have formed to rate the environmental friendliness of consumer products. Dubbed Green Cross and Green Seal, the organizations seek to encourage responsible product development and packaging by testing and certifying the environmental claims made by manufacturers. In so doing, the two groups hope to alleviate some of the confusion that now pervades the marketplace. Many companies tout the environmental benefits of their products, but consumers are often unsure of which claims to believe. Verification by a reputable third party, however, will make consumers more confident in their buying decisions. Thus, while manufacturers must pay to have their products tested by Green Cross and Green Seal, certification from these organizations will probably increase the demand for their products.

While the overall goal of the two organizations is similar, the techniques used for accrediting products are somewhat different. Green Cross verifies particular claims made by a given company, such as the statement that their product contains a certain percentage of recycled material. In contrast, Green Seal looks at the overall impact of

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a company's product. Arguing that a true lifecycle analysis* is not feasible, Green Seal instead conducts what it calls an "environmental impact evaluation." This procedure isolates and examines the product features considered by Green Seal to have the greatest impact on the environment. Certification is then based on an assessment of these features. Thus, Green Seal may take into account the energy used, raw materials consumed, and pollution created in the manufacturing and marketing of different products.

**MATERIALS:** The only specific materials that students need are the individual products that they decide to test. Access to a school or community library is also important. Green Seal's "Fact Sheet for Manufacturers" is attached and can be used as a hand-out. The activity can be conducted by giving students the bibliography provided at the end of this activity, or teachers can ask students to do their own original searches if enhancing library research skills is a goal. Teachers wishing to simplify and shorten the assignment can give students copies of the articles referred in the bibliography at the end of the activity.

OPTIONAL: Teachers may wish to hand out the four items at the end of the activity as an orientation to the problem of conducting a lifecycle analysis or may simply wish to use them in whole or in part in class as background material.

- Green Seal "Nomination Form for a New Product Category"
- Green Seal "Fact Sheet for Manufacturers"
- Green Seal "Request for Comment on Proposed Environmental Standard" -- Toilet and Facial Tissue
- Green Seal "Call for Comments: Proposed Criteria and Standards for Toilet and Facial Tissue"
- Green Seal "Request for Comment on Proposed Environmental Standard" -- Motor Oil, Re-refined
- Green Seal "Call for Comments: Proposed Criteria and Standards for Motor Oil, Re-refined"
- "Table & Worksheet - Sample Lifecycle Analysis: What Kind of Pop Container Is the Most Environmentally Friendly?"

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*See "Lifecycle Analysis: Questions and Answers" at the end of this activity for a definition.

- "Background Sheet - Sample Lifecycle Analysis: What Kind of Pop Container Is the Most Environmentally Friendly?"
- "Lifecycle Analysis: Questions and Answer Sheet"

## PRE-ACTIVITY QUESTIONS:

A. Can you think of other "stamp or seal of approval" organizations? What are their names? (e.g., Good Housekeeping seal of approval; Underwriter's Laboratory seal, *Consumer Report* rating, etc.)

B. Once a list has been generated, ask students if they know the significance of the approval seal from those organizations (e.g., quality, safety, etc.).

**PROCEDURE:** Pretend that students have been selected to run a new company called EcoStamp that tests marketing claims and rates the environmental impact of different products. This company is competing with two existing organizations: Green Cross and Green Seal. (Information about each from recent magazine articles is included as background information.) Have students research the testing methods and criteria used by these organizations. Then have them decide what criteria EcoStamp should use.

Once students have developed their criteria, have them test several products. Possible test products might include copy paper (recycled fiber content, post-consumer waste content, paper brightness, recyclability of packaging), food consumption (types of foods served, disposable versus re-usable cutlery and dishes, domestic versus exotic dishes, travel time to eating establishment), and pop can packaging (aluminum versus glass versus plastic.) A sample lifecycle analysis of this last topic is provided at the end of this activity.

**DISCUSSION/QUESTIONS:** Ask students the following questions:

A. What makes the EcoStamp system that you have developed better than the existing evaluation methods used by Green Cross and Green Seal?

B. Why should companies choose to have their products tested by EcoStamp and not by the others?

C. Did the products that you tested qualify for the EcoStamp? Why or why not?

C. Did the products that you tested qualify for the EcoStamp? Why or why not?

D. What were some of the limitations of your study?

E. Is it possible to conduct a truly comprehensive lifecycle analysis? Why or why not?

F. How accurate are your final results?

G. Has the work done by your company had a positive impact on the environment? If so, in what ways?

H. Invite students to think of general ways that we can streamline the production process and cut down on resource consumption (for example, purchasing locally produced goods to save energy used in transporting materials long distances).

I. Discuss the concept of competitive advantage. Why are some companies able to produce higher quality products at a lower cost? How might reducing waste in the production and packaging process impact the cost of an item?

J. This activity provides an effective means of examining the global economy. Why are so many products sold in America made in Taiwan? What are the implications of such global exchanges on energy consumption?

K. Ask students to list various items (balsa wood, sugar cane, salmon, rice, and coal, for example) that are produced almost exclusively in specific areas. Then encourage students to hypothesize about the reasons for such localized production.

## VARIATIONS:

A. Assign students to write and perform a 30-second advertising spot for the new company. If equipment is available, record each spot on videotape. Then play it back later and have the class decide which company, if any, it would choose to test its products.

B. Assign students to select one of the products tested and draw a colorfully illustrated flow chart of the steps involved in manufacturing and marketing it. Teachers who really want to run with this concept can first teach their students how to make recycled paper* and then draw their flow charts on these sheets. When they are completed, the charts can be hung in a student art gallery and judged for quality of research and quality of artwork.

C. Ask students to write an essay advocating a world ecological stamp on internationally traded items. What are the pros and cons of such a system? What existing entity might administer such a program?

D. Have students nominate products for evaluation by Green Seal (see form attached) and send in comments on items presently being evaluated.

## FURTHER STUDY:

A. Ask students to draw a map of the world and trace the voyage of their product and its component parts. See if they can estimate the total number of miles traveled by each component.

B. Other countries have their own environmental seals (*Garbage*, September/October 1991): Canada's "Environmental Choice," the European Community's "Environmental Label," Germany's "Blue Angel," Japan's "EcoMark," and the Nordic Council's "White Swan." Assign students to research these countries' standards for awarding their environmental approval stamp and compare them to the standards of the United States' "Green Cross" and "Green Seal." What can they interpret about the reasons for the differences in the standards?

**GRADE-LEVEL ADJUSTMENTS:** To simplify this activity, urge students to choose a product and research the various steps needed to manufacture and market it without conducting a technical analysis of the environmental impact of the production process.

## BIBLIOGRAPHY:

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* See activity titled "Making Recycled Paper by Hand."

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"Selling Green." *Consumer Reports*, October 1991, pp. 687-692.

## ACKNOWLEDGEMENTS:

Our thanks to Ben Hitchings for writing this activity.

# Nomination Form
## for a New Product Category

1. **Suggested Product Category**
*Describe the product category for which you believe Green Seal should award its label. Please be as specific as possible, i.e. indoor latex house paint, light bulbs used in homes, etc.*

2. **Potential Environmental Benefits**
*Explain the environmental benefits that would result from encouraging products within your suggested product category. For example, do some products use less energy? Produce less waste? Use more recycled materials? How would one or more products within your suggested product category be better for the environment than others now available?*

3. **Suggested Criteria for Product Selection**
*On what basis should Green Seal identify those products within your suggested category that are better for the environment. Depending on the product category, criteria might include such things as percentage of recycled materials, level of toxic chemicals used, product durability, product packaging, or difficulty in disposing of the product after use.*

4. **Your Name, Address, and Phone Number (Optional)**
*This will enable us to keep you informed of our progress and seek your advice in the future.*

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## FACT SHEET FOR MANUFACTURERS

### What is Green Seal

Green Seal is an environmental labeling and consumer education organization. The Green Seal certification mark helps educate consumers about products that cause less harm to the environment.

Green Seal is the only, independent, non-profit environmental labeling program in the United States.

### Consumer Research Supporting the Green Seal Concept

Consumer awareness of the importance of a product's impact on the environment is at an all time high. Market research commissioned by Green Seal showed that 4 out of 5 consumers said they would buy a product with the Green Seal when choosing among products of equal quality and price. Several national surveys indicate consumers would pay more to purchase environmentally preferable goods (estimates range from 5-15% more). Additionally, the Gallup organization did a survey for *Advertising Age* which indicated consumers would rely on the Green Seal more than government guidelines in making their purchase decisions. Finally, in a recent survey conducted by Abt Associates, slightly over half the respondents had considered the environmental attributes of a product when selecting a product.

Consumers want to do the right things, and buy the right things, but they don't always have the information they need to make an informed decision. Green Seal is the independent, credible source that will educate consumers about products that cause less environmental harm.

This trend of heightened environmental consciousness on the part of the public is not just a U.S. phenomenon. There are successful labeling programs in effect in Canada, Germany, and Japan. Additionally, labeling programs are being initiated or are under consideration in many countries worldwide including France, Austria, Portugal, Norway, Sweden, Finland, the European Community, the Netherlands, Australia, and New Zealand.

### Benefits of Using the Green Seal

A product bearing the Green Seal benefits in the following ways:

- An independent, credible third party environmental product endorsement.
- The use of the Green Seal in product-specific advertising and promotional materials.
- The support of Green Seal's marketing campaign to generate consumer awareness and interest in the Green Seal and the products that bear it.

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## How Standards Are Set

Green Seal sets environmental standards on a category-by-category basis. Green Seal's Environmental Impact Evaluation considers the environmental impacts of products from the manufacturing stage through consumer recycling or disposal. In setting standards Green Seal focuses on significant environmental impacts while taking into account what is technically and economically feasible.

Proposed standards are issued for public comment. Manufacturers, trade associations, environmental and consumer groups, government officials and others are encouraged to participate by commenting on the proposed standards. Comments are reviewed and the proposed standards are revised, as appropriate.

When the final standard is set, manufacturers are notified and can apply to have products tested. All testing is done by independent laboratories. Test results are kept strictly confidential.

## Testing and Annual Compliance Fees

There is an initial testing fee for determining if a product meets the Green Seal standard. Once a product is licensed the use of the Green Seal, there is an annual monitoring fee for ensuring ongoing compliance with the standard. Green Seal's initial testing and compliance monitoring fees vary by product category, but the same charges apply to all products within a category. Green Seal's fees are based on the organization's costs for time and materials.

## The Leadership of Green Seal

Green Seal is led by Denis Hayes, International Chairman of Earth Day 1990 and Executive Director of the original Earth Day in 1970. Green Seal's board of directors includes leaders of environmental and consumer groups as well as business leaders and others who support socially responsible programs.

Printed on hydrogen peroxide bleached, 100% waste paper with 50% post-consumer waste. 6/91

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## GREEN SEAL FACT SHEET FOR MANUFACTURERS

# REQUEST FOR COMMENT ON PROPOSED ENVIRONMENTAL STANDARD

***Green Seal is a non-profit, environmental labeling and consumer education organization working to identify environmentally preferable products. As a part of that effort, Green Seal is currently establishing an environmental standard for toilet and facial tissue and is seeking advice from manufacturers, environmental and consumer groups, government agencies, other interested parties and the general public. The proposed standard is based on a review of currently available information on significant opportunities for environmental impact reduction. Once the standard is established, manufacturers and suppliers of toilet and facial tissue will be invited to submit their products for testing. Those that comply with the standard may obtain the right to use the Green Seal certification mark on their product and in their advertising.***

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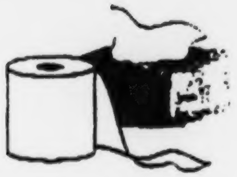
# GREEN SEAL CALL FOR COMMENTS



## Proposed Criteria and Standard for Toilet & Facial Tissue

Green Seal seeks public comment on its proposed standard governing the award of the Green Seal of environmental approval to toilet and facial tissue. Green Seal will accept comments on the proposed standard until August 9, 1991, and will hold a public hearing on August 28, 1991, in Washington, D.C.

The Green Seal proposed standard would require that in order to bear the Green Seal certification mark, toilet and facial tissue must:

- consist of 100 percent waste paper, with a minimum of 10 percent post-consumer waste;
- contain no added pigments, inks, dyes, or fragrances;
- not use waste paper de-inked with specific toxic solvents;
- be packaged with materials that do not contain highly toxic heavy metals, such as lead, mercury, or cadmium; and
- be packed with more useful product per package to minimize waste.

To receive a copy of the complete call for comments, proposed standard and underlying statement of rationale, please write, fax or phone your request to:

Green Seal
Attention: Tissues Standard
Suite 300-A
1875 Connecticut Ave., N.W.
Washington, D.C. 20009-5818
(202) 986-0393 (Phone Requests)
(202) 328-8087 (Fax Requests)

BEST COPY AVAILABLE

# REQUEST FOR COMMENT ON PROPOSED ENVIRONMENTAL STANDARD

# MOTOR OIL, RE-REFINED

***Green Seal is a non-profit, environmental labeling and consumer education organization working to identify environmentally preferable products. As a part of that effort, Green Seal is currently establishing an environmental standard for re-refined motor oil and is seeking advice from manufacturers, environmental and consumer groups, government agencies, other interested parties and the general public. The proposed standard is based on a review of currently available information on significant opportunities for environmental impact reduction. Once the standard is established, manufacturers and suppliers of re-refined motor oil will be invited to submit their products for testing. Those that comply with the standard may obtain the right to use the Green Seal certification mark on their product and in their advertising. Underwriters Laboratories Inc., the nation's most respected not-for-profit testing organization, serves as Green Seal's primary testing and factory inspection contractor.***

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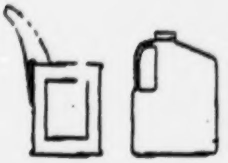
# GREEN SEAL CALL FOR COMMENTS



## Proposed Criteria and Standard for Motor Oil, Re-refined

Green Seal seeks public comment on its proposed standard governing the award of the Green Seal of environmental approval to motor oil. Green Seal will accept comments on the proposed standard until September 30, 1991.

The Green Seal proposed standard would require that in order to bear the Green Seal certification mark, motor oil must:

- be formulated with at least 50% re-refined oil content by volume in the base stock. Effective January 1, 1995, the base stock must contain at least 75% by volume re-refined oil;
- meet restrictions for levels of PCBs, chlorinated solvents, heavy metals and other chemical contaminants in the base stock;
- meet performance standards prepared by the American Petroleum Institute, or the Department of Defense;
- be packaged with materials that do not contain highly toxic heavy metals, such as lead, mercury or cadmium; and
- by January 1, 1994, be packaged in containers manufactured from at least 10% post-consumer waste materials. Effective January 1, 1996, packaging must contain a minimum of 25% post-consumer waste.

To receive a copy of the complete call for comments, proposed standard and underlying statement of rationale, please write, fax or phone your request to:

Green Seal
Attention: Motor Oil Standard
Suite 300-A
1875 Connecticut Ave., N.W.
Washington, D.C. 20009-5818
(202) 986-0393 (Phone)
(202) 328-8087 (Fax)

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## BACKGROUND SHEET
## SAMPLE LIFECYCLE ANALYSIS: WHAT KIND OF POP CONTAINER IS THE MOST ENVIRONMENTALLY FRIENDLY?

**OBJECTIVE:** Our objective in this analysis is to assess the relative environmental impact of three different kinds of pop containers: glass, aluminum, and plastic.

**DATA:** In this sample analysis, we have provided information on the amount of energy and water used, the industrial solid waste and waterborne waste generated, and the atmospheric emissions released in order to produce enough containers to hold 1,000 gallons of soda.* Students are asked to calculate the disposal cost of the post-consumer solid waste generated.

**CRITERIA:** In this sample activity, we have expressed the relative environmental impact of each of the different factors as a cost in dollars. As a result, our sole criterion for determining the product with the lowest environmental impact is to figure out which of the three has the lowest total cost in dollars. (NOTE: This is hard to do accurately unless one uses comparable sets of data. For example, you might ask your students to compare various sets of data when conducting their lifecycle analysis, such as (1) the amount of energy [in Btus], water [in gallons], and pollution generated [in pounds], as well as the amount of recycled material used [as a percentage of the whole] in making the product.)

**ANALYSIS:** Students should begin by completing the table on the following page. The cost of disposal computations below -- when done for aluminum, plastic, and glass containers -- will supply the data needed for Column 5 across on the "Sample Lifecycle Analysis" table and worksheet. To do this, follow these steps:

1. Calculate the number of ounces in 1,000 gallons:

   **1,000 gallons x 128 ounces per gallon = ______ total ounces**

2. Calculate the number of containers needed to hold 1,000 gallons of soda:

   **Total ounces / ounces per container = ________ total number of containers needed to hold 1,000 gallons**

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*Our source for this information is the Florida Department of Education's *4 Rs Project*, p. 41.

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3. Calculate the average number of containers that are recycled:*

   **Containers needed to hold 1,000 gallons x recycling rate for container type = _ ______ average number of containers recycled (make sure to convert the recycling rate to a decimal, e.g., 64% becomes .64)**

   **(Rates: Aluminum, 64%; plastic, 28%; glass, 25%)****

4. Calculate the average number of containers that are thrown away:

   **Containers needed to hold 1,000 gallons - containers recycled = ______ average number of containers thrown away**

5. Calculate the weight of the containers that are thrown away:

   **Number of containers thrown away x weight in ounces of one container x # of ounces in one pound (16 ounces) x number of pounds in one ton (2,000 lbs.) = ______ # of tons thrown away**

6. Cost of disposing of garbage in your community:

   **Number of tons thrown away x cost per ton for landfill disposal (in dollars, including hauling costs and tipping fee)*** = __________ cost in dollars for disposal of post-consumer solid waste**

**CONCLUSION:** Which container did you find to have the lowest environmental impact? How accurate do you believe this particular study is? What are its limitations?

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* The recycling rate for glass includes **reused** glass as well, i.e., returnable/refillable glass containers.

** Recycling rates are as follows, according to October 1991 figures: aluminum cans, 64% (Aluminum Association); plastic soft drink containers, 28% (NAPCOR -- National Association of Plastic Container Recycling), and glass containers, 25%, including refillables (spokesperson at *Resource Recycling*).

*** In Cuyahoga County, call the Cuyahoga County Planning Commission, 216/443-1773, and ask for the County's current average figure. Other locations should call their county planning commission or equivalent.

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# TABLE & WORKSHEET
# SAMPLE LIFECYCLE ANALYSIS – WHAT KIND OF POP CONTAINER IS THE MOST ENVIRONMENTALLY FRIENDLY?

**Container Costs for 1,000 Gallons of Soda***

| | GLASS | ALUMINUM | PLASTIC |
|---|---|---|---|
| Energy | $ 64.00 | $ 76.00 | $ 63.00 |
| Water | 39.00 | 15.00 | 42.00 |
| Industrial Solid Waste | 38.00 | 36.00 | 7.00 |
| Atmospheric Emissions | 261.00 | 323.00 | 240.00 |
| Waterborne Wastes | 56.00 | 69.00 | 69.00 |
| Post Consumer Solid Waste | | | |
| TOTAL | | | |

* Table is from the Florida Department of Education's *4Rs Project*, p. 41.

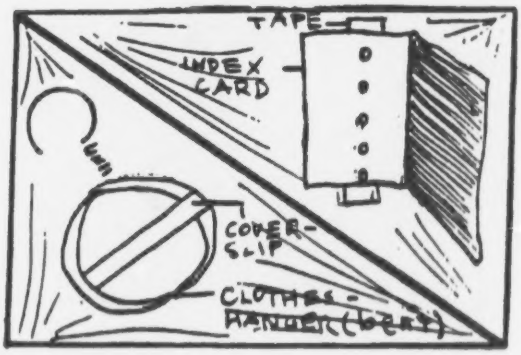
## LIFECYCLE ANALYSIS:
## QUESTION & ANSWER SHEET

| | |
|---|---|
| **Q:** | What is a lifecycle analysis? |
| **A:** | A lifecycle analysis (LCA) is a comprehensive study of all the different processes that go into the making and marketing of a particular product. The goal of this study is to evaluate the overall environmental impact of the product. |
| **Q:** | What particular features of the manufacturing and marketing process should be examined in order to conduct an LCA? |
| **A:** | As many as possible. A truly comprehensive LCA factors in every process related to the making of the product from the extraction of raw materials to production in a factory, to marketing and distribution, to consumption and disposal. However, such a thorough study is very difficult to conduct because of the large number of steps that have to be examined and factored into the calculations. In light of this, students may want to simplify their evaluations to focus on selected elements of the manufacturing and marketing process. |
| **Q:** | On which of these different factors can we actually find information? |
| **A:** | This depends on how hard you look. Sources of information include magazine articles and books available at the library, local and national environmental groups that track the activities of different companies or industry sectors, state and federal government officials that work on environmental issues, and trade associations that represent a given industry. |
| **Q:** | Once we have gathered information on our product, what criteria might we use to evaluate this data? |
| **A:** | Some of the different factors that you may want to consider are the amount of energy and natural resources consumed in the various stages of the production and distribution process, as well as whether these resources are renewable (such as trees) or non-renewable (such as oil or minerals). Other factors include the amount of recycled material contained in the product, the ease with which the product can be recycled, and the quantity of pollution generated by the product, both in its production and in its final disposal. |

# AIRBORNE SOLID WASTE

**Subjects:** Science, health, chemistry, biology, industrial arts

**Format:** Two class periods plus home and field assignments to place and monitor collectors



**OBJECTIVE:** In this activity students will (1) learn to measure the extent of airborne particles (particulates) in various parts of the community, (2) examine particulates they collect under a microscope and draw a record of their collection, (3) determine the likely sources of the material, and (4) learn the importance of accuracy and controls in gathering data.

**METHOD:** Students will make simple air pollutant collection devices, hang them at various sites in the community, then collect them after a week to examine and discuss their findings.

**BACKGROUND:** This lesson will help students appreciate the fact that solid waste affects air quality as well as water and soil conditions. The activity uses two very simple but different kinds of collectors for gathering samples of particulate contamination and then identifying its possible sources within the community. It also teaches students the importance of accuracy in data collection and the need for controls. Students construct collection equipment, place collectors in different areas, retrieve the samples, examine them under a microscope, sketch their findings in a notebook, and discuss their findings with classmates. The activity is broken in two parts with two different sets of materials required. Since there are two kinds of collection devices used, it would be useful to divide the students into 4 teams, for example, two teams assigned to each method.

An adaptation of this activity was done by students at Stamford High School, Stamford, Connecticut. The original purpose was to collect pollen grains during the hay fever season. Students were surprised to find how much soot was in the air. Pollen grains were less numerous than soot particles.

**MATERIALS:** (Part I and Part II take place in the classroom approximately 8 days apart.)

A. Collector A:

- 16 or more 3 x 5 inch cards (or enough for two teams)
- Hole punch (i.e., the size of 3-ring notebook paper holes)
- One-inch wide cellophane tape
- Hand-out illustrating construction

B. Collector B:

- 16 or more wire clothes hangers
- 16 or more 3-inch glass slides
- Petroleum jelly
- Small soup cans
- One-inch wide cellophane tape
- Balance or scales capable of weighing grams
- Applicator sticks for petroleum jelly
- Hand-out illustrating construction

## PRE-ACTIVITY QUESTIONS:

A. To lead into the activity, ask "What constitutes air pollution?"

B. "What are the sources of air pollution?"

C. "How is solid waste considered a factor in air contamination?"

# PROCEDURE:

PART I:

A. For Collector A, ask students to prepare the following:

1. As illustrated in the hand-out, fold the 3 x 5-inch cards in half lengthwise
2. Using a hole punch, punch out 5 evenly spaced holes on half of the card
3. From one side only carefully place a strip of tape on the line of holes, sticky side to the holes, so that 5 sticky pockets are created on the other side
4. Protect these pockets by folding the other half of the card over the holes and securing it with the tape ends until the collector is ready for use. Make as many cards as time allows.
5. Students should have a "control" collector, one that is unexposed, to compare the following week with those placed in the field.

B. For Collector B, ask students to prepare the following:

1. As illustrated in the hand-out, bend the coat hanger around a can into a circular shape wide enough to support the 3-inch slide across its diameter.
2. Place the tape around and across the diameter of the hanger, with the sticky side of the tape out so it will support the glass slide from one side of the wire circle to the other. Number each slide.
3. Apply a thin layer of petroleum jelly to the slide. Avoid touching the jellied surface.
4. Carefully weigh the slide and record the weight of each slide by number.
5. Slides that are not to be used right away should be placed in a box with a lid to prevent contamination or damage.
6. Students should have a "control" collector, one which is unexposed, to compare the following week with those placed in the field.

C. Students should now take their collectors home and hang them in areas that are to be examined: e.g., in a garage, on a back or front porch, in the basement, near a workbench, in the kitchen. Be sure to remind students to open the tape seal on Collector Type A so that particles can reach the sticky pockets.

Collectors should not be placed where they are likely to be damaged by rain or direct wind. Secure them when necessary. The collectors should be left out for 1 week and then returned to class for analysis. (Students may find that some collectors have been lost or damaged.)

Each student should record where the collector(s) was placed for comparisons the following week.

PART II:

D. 1. To examine Collector A results, have students bring their collectors to class and follow these procedures:

a. Examine the collector under a microscope on low power.

b. Ask them to draw and describe in their notebooks what they see.

c. Examine samples of others in the group to compare and contrast with each other's collector results. Have them record in their notebooks the differences and similarities.

d. When the examination is complete, tape the collectors on a sheet of white paper.

e. Get together with your group and devise a 1-5 rating of color density of the samples. Compare and relate the density of the samples. Compare and relate the density of the particles and the source of the samples.

2. To examine Collector B results, have students bring their collectors to class and follow these procedures:

a. Weigh slides very carefully and note any increase in weight. Record it in the notebook.

b. Using the data recorded, find the amount of particulate matter in 1 square mile in a one week period by using the following:

- a gram = $1.102 \times 10^{-6}$ tons
- 1 square in. = $2.49 \times 10^{-10}$ sq. miles
- 3 sq. in. = $7.47 \times 10^{-10}$ miles (size of the slide)

NOTE: If 1 gram = $1.102 \times 10^{-10}$ miles, your net particulate weight times this number will give you the amount of particulate matter you have in tons. Divide the weight you got by the area of your slide in square miles to obtain the number of tons per square mile.

c. Place your results, your name and the source of the sample on the chart provided on the blackboard.

## DISCUSSION/QUESTIONS:

A. What are particles?

B. What is meant by particulate air contamination?

C. What are the sources of particulate contamination?

D. What sources of particulate contamination are there in your community?

E. What are the limitations of the two types of collectors?

F. How did they seem to compare as collectors?

G. What other ways could collections be made to learn about community air contamination?

H. What was the "mortality rate" on detection devices?

I. Ask the students what impressed them most about their findings.

J. What were the students' reaction to the controls as a means of comparing levels of particulate air contamination?

K. Ask students to consider whether using two to three times as many collectors would be helpful in conducting the experiment. Why?

# FURTHER STUDY:

The following could be given as an individual investigation, extra credit, or as a class research and writing assignment:

A. Assign students to find out the federal allowable amount of particulate air contamination.

B. How do the class results compare with this standard?

C. To what extent is particulate air contamination harmful?

D. What community controls do you feel are needed to limit particulate air contamination?

# SOURCES:

Reynolds, William G. and Robert W. Ward. "Simplified Airborne Solid Sampling," *The Science Teacher*, Vol. 38 No. 1, Jan. 1971. P. 49-50.

Warner, Barry, "Particulates Provide Proof of the Pollution Problem," *The Science Teacher*, Vol. 37 No. 5, May, 1970. p. 78-79.

# ACKNOWLEDGEMENTS:

The Institute has adapted this activity from in its book, *A Curriculum Activities Guide to Solid Waste and Environmental Studies*, Volume IV, first published in 1973.

# ACID RAIN

**Subjects:** Biology, chemistry, social studies, physics, journalism, language arts

**Format:** One class period; may be extended for individual and team projects

**OBJECTIVE:** Students will learn about (1) the chemistry and the controversy of acid rain and (2) the relation of incineration to acid rain.

**METHOD:** Students will recreate on a small scale in the lab the conditions that produce acid rain and then test the "rain's" acidity on paramecium or euglena.

**BACKGROUND:** This activity allows you to address both the chemistry and the controversy of acid rain. The first-hand knowledge, the chemistry of it, should be the major focus of one class period; if your class shows an interest in exploring the outcomes of scientific findings historically and the subsequent public action about them, this is a suitable subject with which to begin.

The issues involved in the activity are as follows. Burning non-metals produces oxides called "acid anhydrides" that, combined with water, forming acids; as gases, acid anhydrides may dissolve in rain, producing "acid rain." Incineration reduces the volume of wastes to be disposed, but poses problems that include the production of acid gases that can contribute to environmentally harmful acid rain. Finally, while scientific information may be available to make decisions about how to avoid or mitigate acid rain and other environmental problems, ways to integrate that information into timely political, social, and economic action typically lag behind the deleterious effects.

Another class period could be dedicated to discussion, especially after some individual assignments to research kindred issues -- ozone layer depletion, mercury poisoning in fish, chemical poisoning from landfill leachate, etc.

## MATERIALS:

See the "Student Lab Instructions - Making Acid Rain," at the end of this activity.

## PRE-ACTIVITY QUESTIONS:

A. What causes acid rain?

B. How is acid rain formed?

C. What are the physical and chemical differences between the products of incinerated metals and incinerated nonmetals?

D. What are two sources of toxic acid gases from burning unsorted garbage? (Hydrogen Chloride can be released from burning plastics. Sulfur dioxide is formed when sulfur containing substances are burned.)

E. What are three effects of acid rain on the environment? (Plants and animals can be weakened or even killed, soil microbes damaged, buildings corroded, etc.)

## PROCEDURE:

A. This experiment will investigate the burning of nonmetals, which might occur in the incineration of garbage. Explain that although incineration is already being used by some 70 cities and counties in this country as well as by many European countries, concern is high that gases emitted from such operations have the potential to cause serious environmental harm.

B. This experiment will also investigate the release of acid anhydrides from the burning of nonmetals that might be part of the refuse burned in an incinerator. Acid anhydrides such as sulfur dioxide and nitrogen oxides are a major source of acid rain. Acid rain has been linked to fish kills and destruction of forests, as well as damage to microorganisms that are vital to our environment.

C. Assign students to work in pairs using the "Student Lab Instruction - Making Acid Rain" instruction sheets.

D. When students have finished with the experiment, move on to the questions and discussion topics, below.

## DISCUSSION/QUESTIONS:

A. What does this demonstration show us about how acid rain is formed?

B. What are the potential relationships between waste and acid rain? (Incineration of waste can release acid rain-causing materials into the atmosphere.)

C. How can acid gas emissions from waste incinerators be controlled? (Neutralization of the acids with an appropriate base.) Explain that the best incinerators are equipped with devices called scrubbers or other devices that allow incinerators to comply with air emission standards. As refuse is burned, the gases released are mixed with a lime (calcium oxide) and water solution which is sprayed into the chimney flue. The lime slurry neutralizes the acid gases to nontoxic calcium salts.

D. What other processes contribute to acid rain? (Auto exhaust produces nitrogen oxides; coal fired electric generators and many smelters produce sulfur dioxides.)

E. What are some natural sources of acid rain? (carbon dioxide)

## FURTHER STUDY:

A. Ask students to research the causes of acid rain in the U.S. and the effects on the environment.

B. Canadian attitudes and actions toward the U.S. as a source of acid rain damaging its natural resources will show students the complexities of environmental problems, like those of the ozone layer, that cross national boundaries. Ask students to research the history of Canadian and American actions to address the acid rain problem.

C. Determine which acids could be formed from burning the following: nitrogen, phosphorus, and carbon. Which would be the most acidic?

D. Invite a speaker from the Ohio Environmental Protection Agency or the local municipal engineering department to discuss incinerators and waste management problems.

E. Assign students to investigate the acid rain problems which Germany and eastern European nations now face and then report their findings to the class.

F. Set up rain-water collection containers. Test melted snow and rainwater for its relative acidity throughout the school year. Locate collection stations at student homes to determine local acid rain patterns.

G. Request that your local EPA office send you the State's permit criteria for commercial waste incinerators. Investigate how these criteria have changed over the past 10 years and report and interpret your findings.

## SOURCES:

Parts of this activity are based on material from: *Educators for Social Responsibility, Investigations: Toxic Waste.* (A Science curriculum in the participation series.) Boston Area Educators for Social Responsibility: Cambridge, Mass. 1984.

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Hahif, Muhammad. "Acid Rain." *Science and Children.* Nov./Dec. 1984, pp. 19-22.

Hershkowitz, Allen. "Burning Trash: How it Could Work." *Technology Review, July 1987,* pp. 26-34.

Institute for Environmental Education. *Tuning the Green Machine: An Integrated View of Environmental Systems. Chagrin Falls, OH: Institute for Environmental Education, 1978.*

Mohnen, Volker A. "The Challenge of Acid Rain." *Scientific American.* August 1988, pp. 30-38.

## ACKNOWLEDGEMENTS:

Our thanks to the Washington State Department of Ecology for permission to use/adapt this activity from its publication *A-Way with Waste.*

# STUDENT LAB INSTRUCTIONS - MAKING ACID RAIN

Name:____________________ Date: ____________________

## A. INTRODUCTION:

Both federal and state governments now impose strict requirements on the disposal of wastes in landfills. Many municipal governments faced with the closing of old dumps are viewing incineration as an attractive alternative. Incinerators not only reduce the volume of garbage disposed, but they also generate electricity. However, concern about the potential for environmental harm is high.

The burning of nonmetals produces oxides called acid anhydrides which form acids when dissolved in water (acid rain). Burning plastics can release hydrogen chloride gas which is also very acidic when dissolved in water. Acid rain has been likened to fish kills, the dying off of forests and the destruction of microbes that are vital parts of our ecosystem. Damage to marble statues and concrete buildings that contain limestone (calcium carbonate) has also been reported.

The burning of metals produces oxides called basic anhydrides which form bases when dissolved in water. Basic anhydrides are mostly solids. So when metals are incinerated they produce solid basic anhydrides, some of which end up as particulates in incinerator fly ash. Many heavy metals are toxic or carcinogenic when ingested over a long period of time.

Naturally occurring substances such as carbon dioxide have always caused rainwater to be slightly acidic. The dilute solution of carbonic acid that results means that most rainfall has a normal pH of around 5.6. In the northeastern United States, the acid anhydrides of sulfur and nitrogen emitted from a variety of sources have lowered the pH of rainwater to around 4.0 to 4.5. Sometimes a pH as low as 3 has been observed. (Orange juice has a pH of around 4.5; a pH of 3 is about that of vinegar.) The main reactions are:

$$H_2O + SO_2 \text{ ----------> } H_2SO_3$$

$$H_20 + SO_3 \text{ ----------> } H_2SO_4$$

$$H_2O + 2NO_2 \text{ ----------> } HNO_3 + HNO_2$$

## B. MATERIALS:

- Sulfur flowers or powder
- Gas bottle -- size 200 ml.
- Deflagrating spoon
- Cover plate (glass plate)
- Litmus paper and pH paper
- Stirring rod
- Magnesium ribbon
- Test tube
- Paramecium or Euglena (or mixed) culture in solution
- Microscope slides
- Microscope
- Lab hood with air evacuation fan

## C. PROCEDURE:

1. Pour about a 1/2 inch of distilled water (10 ml) in a gas bottle. Place a B-B pellet-sized amount of sulfur in a deflagrating spoon and start it burning. Ignite sulfur in a fume hood, to protect students from fumes.

2. Quickly lower the spoon into the gas bottle near the water. Cover the mouth of the bottle as much as possible to prevent the escape of the $SO_2$ gas being produced. (See illustration, below).

3. When the sulfur has burned completely, remove the spoon and cover the top completely to trap the $SO_2$ gas.

4. Shake the bottle for about a minute to mix the $SO_2$ and water. (Be certain

the cover is securely in place before shaking the bottle)

5. Using a stirring rod, place a drop of distilled water on pieces of red and blue litmus paper and on a piece of pH paper. Record your observations.

   Red litmus paper _____

   Blue litmus paper _____

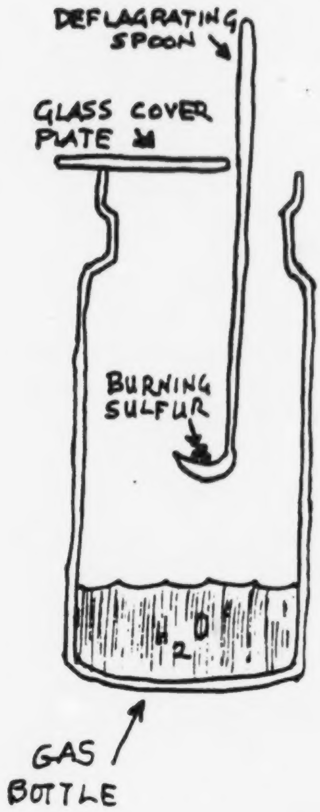
   pH = _____ of distilled water

6. Extract about 2 ml of "acid rain" from the bottle into a test tube. Repeat the above tests on this sample. Record your results:

   Red litmus paper _____

   Blue litmus paper _____

   pH = _____ of "acid rain" water



7. Place a drop of bacteria culture (Paramecium or Euglena or mixed) on a microscope slide. Examine it under the microscope for three minutes. Record your observations.

   Add three drops of "acid rain" to the slide. Be sure the drops fall evenly over the original drop. Observe the effects under the microscope for three minutes and record your observations.

8. Place a 1 cm length of magnesium into the test tube. Observe it for at least three minutes. Record your observations. Repeat this experiment with a piece of chalk. Record your observations.

9. (Optional) Repeat Step 7 with salt solutions of varying concentrations. Repeat Step 7 using stock solutions of acid of varying concentrations. Record your observations for each different pH and salt concentration.

## D. QUESTIONS:

(Answer on a separate sheet of paper.)

1. What is the equation for the burning of sulfur in air?

2. How was the acidity of the water affected by the gas produced from the burning of the sulfur?

3. What happened to the bacteria culture when the "acid rain" was added? What might happen to a small lake or pond if such a solution were added over a long period of time? What kind of lakes might be more affected than others?

4. If a liquid similar to our "acid rain" solution was allowed to stand on a marble statue or the steel supports of a bridge, which effects would you predict?

5. Is pH a good predictor or indicator of water contamination?

6. What other information or scientific data might you want to answer questions 3-5?

# WASTEWATER TREATMENT

## A. CITY WATER

**Subjects:** Biology, chemistry, physical science, environmental science

**Format:** Individual student or teams of students in classroom or laboratory; requires 3 full periods (days 1, 2, and 5) and 5 minutes only on days 3 and 4

**OBJECTIVE:** Students will (1) learn the difference between point source and nonpoint source pollution, (2) identify the major sources of city wastewater, and (3) learn the different stages of city wastewater treatment, including the contaminants removed at each stage.

**METHOD:** Students will review background material on a city's wastewater treatment system and construct a working model of a wastewater treatment system.

**BACKGROUND MATERIAL:** A large population and an increase in industrial activities place a great demand on any major city's water supply and its wastewater treatment systems. Today, each person in the United States generates approximately 50 - 100 gallons of wastewater daily in personal use, food preparation, and cleaning activities. If we add the amount of wastewater generated by industry and agriculture, the average amount of wastewater generated per person is 2,100 gallons per day.

Water pollution sources are classified by two categories: "point sources" or "nonpoint sources." **Point sources** are defined as "end-of-pipe" discharges: this kind of pollution includes contamination from such sources as wastewater discharged from city wastewater treatment plants, industrial treatment systems such as those found in steel manufacture, and wastewater from animal feedlots. **Nonpoint sources** are undefined discharges from large, often amorphous areas. Examples include stormwater runoff from buildings, city streets, and highways; runoff from erosion at construction sites; and runoff from mining and agricultural land.

City wastewater is usually 99.94 percent water and .06% solid organic and inorganic materials. **Organic** materials are carbon-based substances which are or were parts of living organisms. Most organic pollution in the city's wastewater is from human wastes in the form of **suspended solids**, which are biodegradable and can be decomposed by bacteria into simpler compounds. City wastewater also contains viruses, bacteria, and other organisms which can cause disease. **Inorganic** materials in city wastewater are those which never were alive: they include such materials as sand and undissolved minerals. Whether organic or inorganic, the contaminants found in sewage can vary considerably with the season, time of day, the weather, and from one site to another.

How much treatment city wastewater has to undergo varies with how pure the final water product has to be that leaves the treatment plant. This depends on the "next" use of the **effluent** (the water discharged): will it be discharged into a stream or lake? Will it be routed to industry for its processes? Will it go directly to the city water supply for drinking? The more contaminants removed, the greater the expense of water treatment. The more **sludge** (the solid material that is undigested and undecomposed in the treatment process) produced, the more expensive the treatment process, since sludge, too, must be disposed of or treated to remove harmful materials, such as heavy metals, before being used as mulch, fill, or other application.

# MATERIALS:

- "Wastewater Treatment Plant" sheet and "Wastewater Treatment Plant Model" sheet at the end of the activity (one per student)
- For each model:
    - Wire gauze
    - Funnel
    - Rubber or latex tubing
    - 4 pneumatic troughs (NOTE: a workable substitute for a pneumatic trough can be built from a plastic dishpan: Cut a small hole in the upper portion

of one end of the dishpan, and another small hole at a lower level at the opposite end of the first. Then, insert a short piece of glass tubing in each hole and seal the entry hole around each piece with silicone caulk or modeling clay [plasticine]. Be sure the glass tubing is long enough to attach the rubber tubing securely.)

- pH paper
- Water hardness test kit (from a swimming pool supply company, plumbing supply store, or lab supply company)
- Peanut with hulls & toilet paper
- Crushed peanuts
- Detergent
- Cooking grease
- Potting soil
- Fine and coarse sand
- Charcoal
- Small collecting jars or cups

## PRE-ACTIVITY QUESTIONS: Ask students the following:

A. What have they or others in their household put down the drain that is not usual wastewater from dish washing, showers and tubs, or toilet flushing? (e.g., latex paint flushed with water from paint jobs; household chemicals, such as residues from oven-cleaner fluid or paste), dyes from art projects such as tie-dying, etc.

B. How many homes have in-sink garbage disposals? Where does the material go that is ground up? (If they use city water and sewage, the material goes directly into the city wastewater stream to be treated. If they are in a more rural area where septic tanks are still used, the material goes directly to the leaching bed for bacterial digestion.)

C. What material have they seen entering a storm sewer during a heavy downpour? What kind of materials are these? Organic? Inorganic? (e.g., cigarette butts, paper and foil food wrap, plastic bottles, glass, newspaper, bottlecaps, roadkills, motor oil, etc.)

D. What is washed down the storm sewers or from highways into streams, rivers, and lakes that may not be seen readily? (e.g., highway salt, particles of metal and rubber from road traffic, oil and gasoline residues, etc.)

E. Some years ago a citizen witnessed a lawn-care truck flushing out its contents in a storm sewer in Shaker Heights. What could be the ramifications of this? (The sewage treatment plant might be overloaded with the amount of chemicals in the water. Some of the pesticides might go directly into lakes or groundwater.)

## PROCEDURE:

A. DAY 1:

1. Prepare wastewater by adding raw peanut hulls or ashes from burned hulls, crushed peanuts, some detergent, grease, and a small amount of potting soil to tap water. Have the wastewater ready for students to use.

2. Define and give examples of "point sources" and "nonpoint sources" of water pollution. Explain that this activity will focus on municipal wastewater, a point source of water pollution. Briefly review the five major sources of municipal wastewater:

   a. Personal uses, such as bathing, cooking, flushing toilets;

   b. Household cleaning uses, such as washing clothes and dishes;

   c. Institutional uses, such as washing laundry and dishes and preparing food in hospitals and schools;

   d. Food establishment uses, such as washing dishes and preparing food;

   e. Business and industry uses, such as preparing and using metal-plating solutions, machinery cleaning solutions, and laundry and dry-cleaning solutions.

3. Explain that although the majority (99.94%) of municipal wastewater is water, the other .06% of wastewater contains potentially harmful pollutants that include:

   a. Bacteria & viruses, such as those found in human waste (*E. coli* is a common bacterium);

   b. Chemicals, such as salt (NaCl), petroleum, oils and fats, pesticides, cleaning compounds, soaps and detergents;

   c. Suspended solids (e.g., human waste) and settled solids (e.g., sand);

   d. Minerals.

4. Ask students why municipal wastewater has to be treated. Explain that after municipal wastewater leaves a treatment plant, it eventually enters another body of water (e.g., lake, pond, river). Review the following reasons for treating wastewater:

   a. To eliminate adverse health effects on downstream water users, including plants and animals;

   b. To prevent depletion of the dissolved oxygen in the receiving water (needed by fish and other aquatic organisms);

   c. To prevent the growth of undesirable organisms in the receiving body of water; and

   d. To eliminate negative aesthetic effects downstream.

5. Distribute copies of the "Wastewater Treatment Plant" sheet (at the end of this activity) and review the components of primary treatment, secondary treatment, and tertiary treatment. Ask students to compare the effects of the three levels of treatment in terms of the percentage of oxygen-demanding waste and suspended solids removed and ask

students to identify the contaminants that are extracted at each stage.

B. Day 2: Distribute copies of the "Wastewater Treatment Model" (at the end of this activity) and have students help you construct a working wastewater treatment plant model. (NOTE: To improve the downward flow of water from one stage to another, each trough should be a few inches lower than the one before it.) Pass around samples of the prepared wastewater and instruct students to work in groups of 3-4 and test the water for pH and hardness (calcium and/or magnesium content). Ask them to record their observations of the original wastewater's pH, odor, hardness, color, and turbidity on their "Wastewater Treatment Model" sheets. Add the prepared wastewater to the model and allow it to settle overnight.

C. Day 3: Slowly add more wastewater to the model until the liquid flows out of the grit chamber into the sedimentation tank. Allow this new wastewater to settle overnight.

D. Day 4: Add more wastewater until the liquid flows out of the sedimentation tank and into the trickling filter. Allow the wastewater to settle overnight.

E. Day 5:

1. Add more wastewater until the liquid flows into the receiving water container. Instruct each group of 3 - 4 students to obtain a sample of the effluent in a collecting jar and test the sample for pH and hardness. Ask them to record their observations of the treated effluent's pH, odor, hardness, color, and turbidity on their Wastewater Treatment Model sheets.

2. Ask each group to share its observations of the original wastewater and the treated effluent and discuss the effectiveness of the treatment model.

## FURTHER STUDY:

A. Ask students to continue with the companion activity that follows here, "Country Water," to compare the way two different wastewater treatment systems work. That activity may also be done by an individual or a group of students.

B. There are a number of wastewater treatment plants in the community which students might be able to visit as a class or in small groups. Contact your local Regional Sewer District and ask the Public Information Officer for details.

C. Assign students to research the alternative uses of municipal wastewater (e.g., for watering a municipal golf course).

D. Ask students to consider the following scenario: we can no longer discharge treated wastewater into our water source (e.g., lakes), but instead we have to use the treated wastewater for drinking water directly. How safe do they regard the treated water from the current treatment process? Would they drink it now? If they would not, what are the implications of its being dumped into the receiving waters? This can be handled as a discussion or as a writing assignment.

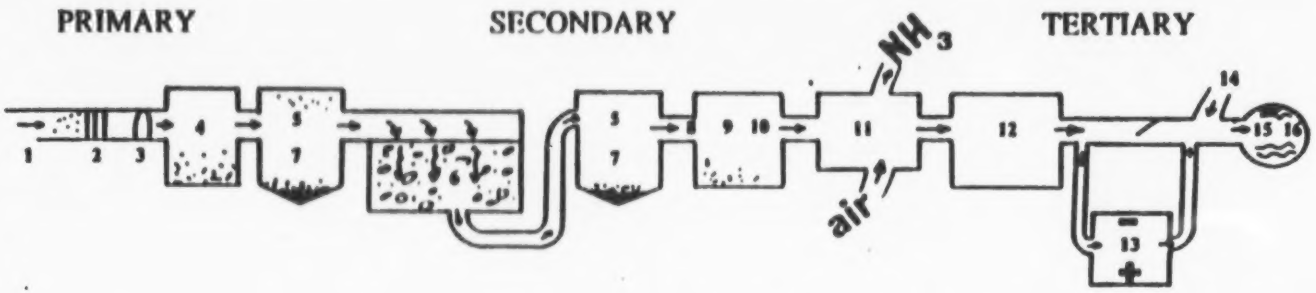
E. Assign research on recent contamination of water bodies from environmental spills and other accidents. What pollutants were dispersed? With what result? What special clean-up was required? How did that treatment regimen differ from the conventional treatment of municipal wastewater just reviewed in this activity?

F. Discuss what change the REDUCTION of water use by individuals would have on water supply, contamination levels, wastewater treatment costs, etc.

G. Assign students to investigate the possible savings from using composting toilets, such as the "clevis multum" (a type of composting toilet). Ask them to calculate the potential dollar savings and gallons of water savings for their city, based on its water treatment costs. To do so they will have to research a couple of statistics: the average number of gallons attributable per individual per day for toilet flushing and the population figures for the city. These data should be easily available from the EPA, Department of Natural Resources, or the Regional Sewer District itself; and the local Chamber of Commerce, respectively.

# WASTEWATER TREATMENT PLANT

A wastewater treatment plant uses a series of tanks, screens, and filters and a variety of processes to remove pollutants from wastewater.



**Primary Treatment** removes material that floats or will settle. Screens catch floating objects and tanks hold heavy matter that settles.
*Efficiency of removal:* 35% O.D., 50 % S.S.

1. Sewers collect and deliver wastewater to treatment plants.
2. Screens remove large items prior to treatment.
3. The comminutor catches and shreds heavy solid matter.
4. Grit Chambers are tanks where dirt, sand, and small rocks settle.
5. Sedimentation tanks remove solids from sewage. Solids settle to the bottom or float on the top as scum. Scum is skimmed off the top. (See #7 for settled solids.)

**Secondary Treatment** is the second step in most treatment systems. Bacteria consume the organic parts of the wastes. The sewage and bacteria trickle through filters or work together in the activated sludge process.
*Efficiency of removal:* 95% O.D., 95% S.S.

6. The trickling filter, usually a bed of rocks or stones, is a support medium for bacterial growth. Sewage is trickled over the bed and bacteria break down organic wastes. The bacteria collect on the stones through repeated use of the filter.
7. Sludge is solid matter that settles to the bottom, floats, or becomes suspended in sedimentation tanks. It must be disposed of by composting, filtration and incineration or by transporting to appropriate disposal sites.
8. Suspended solids are small particles of solid pollutants which are not separated from the water by conventional means.

**Tertiary Treatment** includes biological treatment, which removes nitrogen and phosphorous nutrients, and physical-chemical separation techniques such as distillation, adsorption, electrodialysis, and reverse osmosis.
*Efficiency of removal:* 98%-100% O.D., 98%-100% S.S.

9. Coagulation is the clumping together of solids; they settle out of the sewage faster. Coagulation occurs with the use of certain chemicals such as lime, alum, and iron salts.
10. Flocculation is the process by which clumps of solids are enlarged by chemical, physical, or biological action.
11. The stripping chamber converts nitrogen compounds to ammonia gas, which is exhausted.
12. Adsorption is advanced treatment in which activated carbon removes organic matter from wastewater.
13. Electrodialysis uses direct current to separate soluble minerals from the water.
14. The chlorinator adds chlorine gas to kill harmful microbes.
15. Effluent is the liquid that comes out after the completion of the treatment process.
16. The receiving waters are the streams, rivers, lakes, oceans, or other water courses that receive treated or untreated wastewater.

O.D. = oxygen-demanding waste
S.S. = suspended solids

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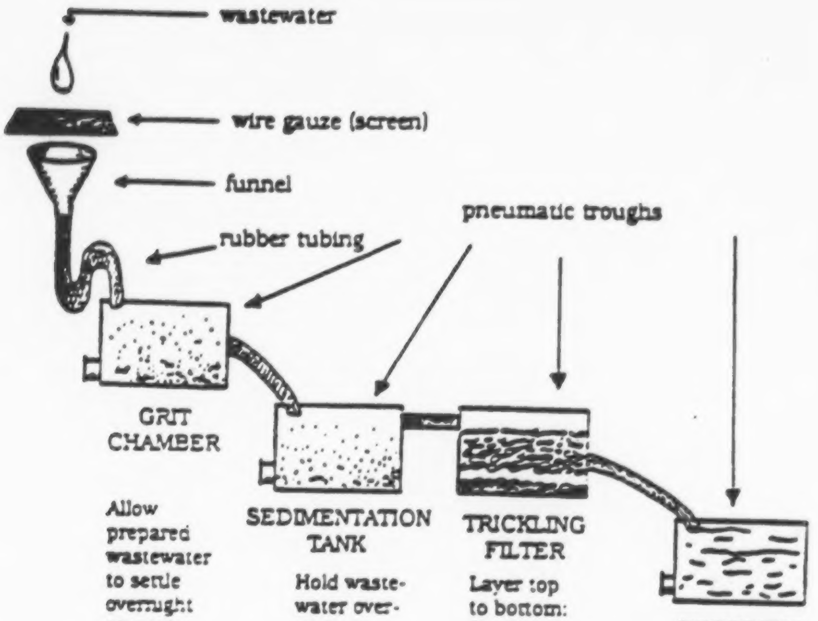
Figure and text from the Florida Department of Education's activity, "City Water," in its *4 Rs Project*.

# WASTEWATER TREATMENT PLANT MODEL

(Secondary Treatment Only)


wastewater
wire gauze (screen)
funnel
rubber tubing
pneumatic troughs
GRIT CHAMBER
SEDIMENTATION TANK
TRICKLING FILTER
RECEIVING WATER

**GRIT CHAMBER**

Allow prepared wastewater to settle overnight or over a weekend. Slowly add more wastewater so liquid flows out.

**SEDIMENTATION TANK**

Hold wastewater overnight or over a weekend. Repeat the addition of wastewater as in the first step.

**TRICKLING FILTER**

Layer top to bottom: fine sand, charcoal, coarse sand, fine sand, coarse sand.

**RECEIVING WATER**

Use samples of effluent to test for pH, odor, hardness, color, and turbidity. (The container into which the effluent is released for testing represents the receiving water.)

| OBSERVATIONS: | pH | ODOR | HARDNESS | COLOR | TURBIDITY (cloudiness) |
|---|---|---|---|---|---|
| ORIGINAL WASTEWATER | | | | | |
| TREATED EFFLUENT | | | | | |

Figure and text from the Florida Department of Education's activity, "City Water," in its *4 Rs Project*.

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# B. COUNTRY WATER

**Subjects:** Biology, chemistry, physical science, environmental science

**Format:** Individual student or teams of students in classroom or laboratory; 2 class periods

**OBJECTIVE:** Students will (1) learn the differences between blackwater and graywater wastes, (2) be able to explain how a septic-tank drainage field system is built and works, (3) be able to list ways that such a system can be abused, (4) describe the symptoms of a failing or failed septic system; and (5) be able to compare and contrast a municipal wastewater system with a septic system.

**METHOD:** Students will construct a model of a septic system, investigating background information on rural wastewater treatment as required.

**BACKGROUND:** Many rural areas do not have wastewater treatment service provided by local governments or other agencies. Therefore, household wastewater is treated onsite. The most common means is the use of a septic tank with a soil absorption system, discussed below. Other means for treating wastewater in rural areas include (1) aerobic (oxygen required) treatment, (2) off-lot systems in which wastewater from several households is carried to a common disposal and treatment site (such as a soil absorption field), (3) evapotranspiration systems (With an evapotranspiration system, grasses and other plants are used to cover the field which receives the wastewater, taking in water and selected minerals while leaving organic material to decompose). The water then leaves the plants through the normal transpiration processes by which plants lose water to the air); (4) composting toilets, (5) low-flush toilets, (6) incinerating toilets, (7) recycling toilets, and (8) dual treatment systems in which blackwater (water containing only human waste) is separated from graywater (water used for dish washing, laundry, etc.).

Onsite disposal systems such as septic tank systems discharge water from a storage tank that is buried in the ground to a substrate drain field. In the tank, anaerobic (no oxygen required) bacteria break down the organic matter, which settles to the bottom and allows clear water to flow out of the tank and into perforated tiles which trickle the clear water into surrounding soil, where aerobic bacteria complete the breakdown of contaminants. Periodically, sludge (solid residue at the bottom of the septic tank) must be removed and treated at an approved site.

The area surrounding the septic tank is called a drain field: it is an area where the soil type, area size, and wastewater pipe levels usually prevent sewage (i.e., the blackwater and graywater waste entering the septic tank) and the effluent (i.e., the bacterially cleansed liquid leaving the septic tank) from contaminating drinking water sources. The effluent is further cleaned by aerobic bacteria (oxygen required) in the soil as the water enters the drain field. A failing septic tank system can contaminate groundwater; failing or failed systems are often marked by the odor of sewage along the drainage bed before and after the septic tank. In cases where the bacterially cleansed effluent actually has a distinct outflow, the water should be clear and odorless. With a failing or failed system, it will be malodorous and, depending on the degree of failure, raw sewage may be present. A failing or failed system obviously poses potential health hazards as well as the nuisance of its odors.

## MATERIALS:

* Handout (or transparency) of the "Septic Tank Design" handout (see end of the activity)

* One "Septic Tank Model" sheet per student (see end of activity)

* For each septic tank model, the following is required:

    - Funnel

    - Rubber tubing

    - Glass bend

    - Pneumatic trough (NOTE, as in "City Water" activity, above: a workable substitute for a pneumatic trough can be built from a plastic dishpan: Cut a small hole in the upper portion of one end of the dishpan, and another small hole at a lower level at the opposite end of the first. Then, insert a short piece of glass tubing in each hole and seal the entry hole around each piece with silicone caulk or modeling clay (plasticine). Be sure the glass tubing is long enough to attach the rubber tubing securely.)

- 3 "T" connectors
- 250 ml. side-arm flask
- 1 hole-stopper for 250 ml flask
- Wire gauze
- Coarse and fine gravel
- Soil
- Small beaker
- Pinch clamp
- pH paper
- Water hardness test kit (from pool supply, lab supply, or plumbing supply company)
- Sterilized manure (garden supplies shop)
- Peanuts with hulls & toilet paper
- Ashes from burned peanuts and hulls (prepare prior to lesson)
- Detergent
- Cooking grease
- Sterilized animal manure (available at garden supply store)

**PROCEDURE:** Materials in both "A" and "B" should be prepared in advance so that students can assemble the two types of wastewater treatment systems:

A. Prepare the blackwater by adding sterilized animal manure to containers of tap water.

B. Prepare graywater by adding materials such as raw peanut hulls, ashes from burned peanuts, crushed peanuts, detergent, and grease to containers of tap water.

C. Define the terms "blackwater" and "graywater," indicating that in rural areas the blackwater is usually treated in septic tanks, while the graywater is often stored in stone-lined deep wells and later used for irrigating lawns and gardens.

D. Project the Septic Tank Design transparency to explain how septic tanks and drain fields are made and how they work.

E. Identify practices which abuse septic tank systems, e.g., (1) using excessive amounts of water, (2) flushing harsh chemicals into the septic tank, and (3) driving heavy vehicles over the tank and drain fields. Describe the symptoms of a failing system (damp or wet ground in the drainage area, presence of an oily film in the drain field, noticeable sewer odor, wastewater backed up into the house, malodorous and/or uncleaned effluent flowing out of systems with an outflow area.)

Ask students how a failing or failed septic system can cause environmental and health problems.

F. Distribute copies of the Septic Tank Model sheet and review the following steps of the lab activity with them:

1. Each group (can be done with individual students as well) will build a model septic tank using the diagram on the student sheet as a guide. When the model is built, the students will use it to treat prepared wastewater. Each group will run wastewater to the septic tank (250 ml. flask) until it rises to the outlet. The model must then be allowed to stand for at least 24 hours (or a weekend) at room temperature.

2. After observing the results of the previous day's work, each group should add a small amount of the same type of wastewater to the septic tank (250 ml. flask). A pinch clamp should be used on the tubing until the students are ready to collect the effluent. Any effluent coming from the drain tubing should be caught in a small beaker.

3. Each group should examine the original wastewater and final effluent for pH, odor, hardness (calcium and/or magnesium content), color, and turbidity. Students should record their observations on their Septic Tank Model sheets.

G. Now, assign students to two lab groups and direct one group to do the activity with blackwater and the other with graywater. Distribute materials and prepared wastewater and complete the activity.

H. Ask each group to share its observations about the original wastewater and the treated effluent. Compare the two sets of results (blackwater and graywater) and describe how treatment in the septic tank model affected each type of wastewater. Remind students that in an actual septic tank system, bacteria decompose the waste over time. However, in this lab activity, a filtering system was used to simulate the effects of bacterial decomposition.

I. Conclude the activity with a brief review of existing alternatives to septic tank systems in rural areas.

## FURTHER STUDY:

A. Assign students to investigate the other alternatives to septic systems (mentioned in the "Background" section, above), reporting on comparative costs, effectiveness, soil type and related considerations that affect their use, etc. As an extended project, students could build working models of several of these systems. Ask them to show you "engineering drawings" for each before proceeding.

B. Ask students to write an analysis of the two systems -- municipal wastewater treatment vs. rural wastewater treatment. Since both are means for managing a potential harm to the environment, ask what conditions determine when one system is appropriate but the other is not. The ecological concerns -- system cost, carrying capacity of the soil and drain field, density of population, shallow versus deep groundwater sources, relative fragility of the aquifer, etc. all could be considerations.

C. Assign students to perform a percolation test on the soil in the area. The local health department can provide instructions for doing this. Investigate how soil type influences what must be done to prepare a site before building on it. Ask them to investigate local regulations for wastewater treatment systems -- what kinds may be installed?

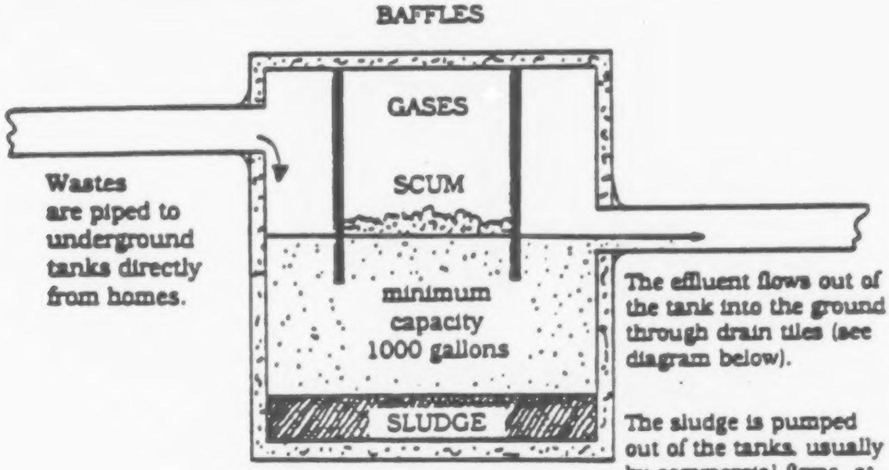
D. Assign students to research what is done with organic materials siphoned out of filled septic tanks. Where do the companies take these wastes? How are they processed? What environmental concerns, if any, are created by these disposal techniques? Are there any "pollution-type" exchanges taking place: i.e., is a groundwater pollution problem being turned into an air pollution problem (e.g., if wastes are incinerated? Or another water pollution problem if, for example, the wastes are dumped but susceptible to leaching from rain and snowmelt? What rules and regulations govern the handling of these wastes? Who is responsible for enforcing them? (Invite an environmental enforcement agent to meet with the class.)

## ACKNOWLEDGEMENTS:

Our thanks to the Florida Department of Education for its permission to use some sections and adapt others from its original activities, "City Water" and "Rural Water" in its *4 Rs Project.*

# SEPTIC TANK DESIGN

Septic tanks are used for domestic wastewater when sewer lines are not available to carry wastewater to a treatment plant.



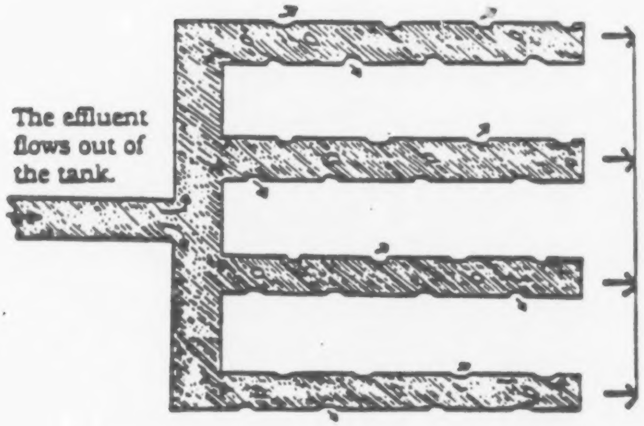
Wastes are piped to underground tanks directly from homes.

The effluent flows out of the tank into the ground through drain tiles (see diagram below).

The sludge is pumped out of the tanks, usually by commercial firms, at regular intervals.

The bacteria in the wastes decompose the organic waste and sludge settles on the bottom of the tank.

OVERHEAD VIEW OF DRAIN TILES



The effluent flows out of the tank.

Effluent seeps into the ground through holes in drain tiles.

Figure and text from the Florida Department of Education's activity, "Rural Water," in its *4 Rs Project*.

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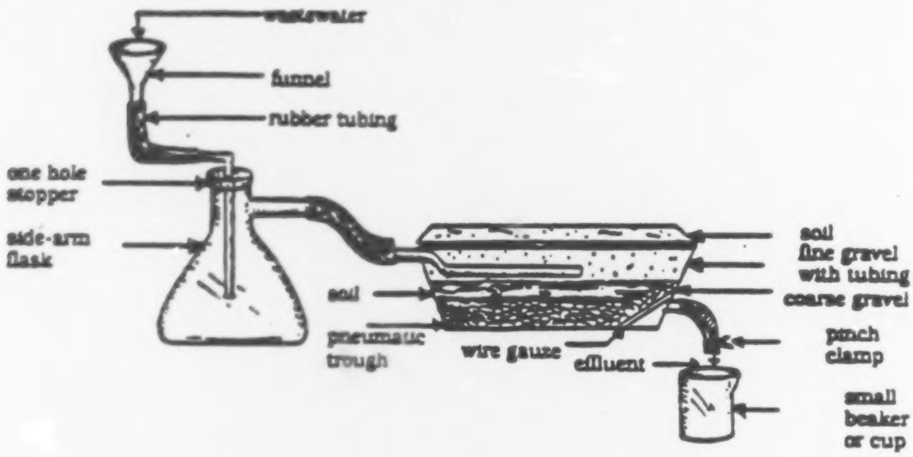
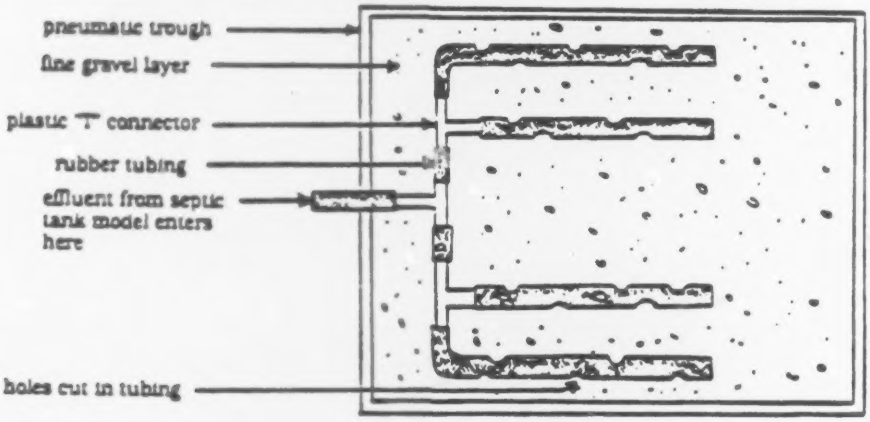
# SEPTIC TANK MODEL


wastewater
funnel
rubber tubing
one hole stopper
side-arm flask
soil
pneumatic trough
wire gauze
effluent
soil
fine gravel with tubing
coarse gravel
pinch clamp
small beaker or cup

## Overhead View of Drain Tubing in Fine Gravel Layer


pneumatic trough
fine gravel layer
plastic "T" connector
rubber tubing
effluent from septic tank model enters here
holes cut in tubing

| OBSERVATIONS: | pH | ODOR | HARDNESS | COLOR | TURBIDITY (CLOUDINESS) |
|---|---|---|---|---|---|
| Original Wastewater | | | | | |
| Treated Effluent | | | | | |

Figure and text from the Florida Department of Education's activity, "Rural Water," in its *4 Rs Project*.

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# TAKING CARE OF MOTHER (EARTH)

**Subjects:** All subjects are possible; depends on teacher's choice

**Format:** One class to several throughout the school year; may include site visits

**OBJECTIVE:** Students will be exposed to the many skills required in environmental careers.

**METHOD:** There are several methods possible, singly or in combination: (1) students visit job sites to learn about the skills required of employees or (2) professionals visit the classroom to discuss their jobs with students.

## BACKGROUND:

### A. A PERSPECTIVE ON "CAREERS"

Adults commonly ask students of any age, "What do you want to be when you grow up?" Adults with more than one career know the limits this kind of question places on children's thinking. A child may wish to be a basketball player, a ballerina, a doctor, a fire-fighter, an environmental scientist, a lawyer, a physicist, a broadcast journalist, a banker, or a detective. But what do these people actually do day to day? What does a basketball player do during the "off" season? What does a ballerina **do** when she is not practicing for a performance? What does a lawyer **do** when defending in court? How does a fire-fighter learn how to hose down a burning house or rescue people from burning buildings?

The purpose of this environmental activity is three-fold: (1) to introduce students to environmentally related jobs; (2) to hear, first-hand from those in the field; and (3) to introduce them to the concept of multiple skills for multiple careers, jobs, professions in a lifetime. Educators, parents, and career counselors do a disservice to children if they lock students early into a career path *without* stressing the importance of preparing for other skills as well. Tomorrow's students need to be versatile workers. Our society has undergone tremendous change during the last 50 - 100 years. Students will continue to see such change in their lifetimes as they work for a living.

## B. SOME PERSPECTIVES ON PRESENT AND FUTURE ENVIRONMENTAL JOB OPPORTUNITIES

The following are a few examples of recent demands in the environmental jobs area:

- Environmental risk assessment -- investigation of the land-use history of property; investigation and testing of soils for chemical and radiation pollution. (Skill areas include research, law, economics, history, written & oral communication, soil testing, chemical analysis, pollution clean-up, etc.)
- Radon abatement -- testing, measuring, and reducing or eliminating radon gas from households: radon is a naturally occurring radioactive gas that poses health risks homes and workplaces. (Skill areas include geology, air sampling, laboratory analysis, etc.)
- Pollution prevention -- auditing and analyzing manufacturing and production processes to reduce or eliminate hazardous and solid wastes; can include redesign of products, redesign of equipment, etc. (Skill areas include engineering, mathematics, statistical process control, public relations, communications, knowledge of local, state, and federal regulations, chemistry, physics, and many others.)
- Wetlands replacement -- contouring, planting, and populating of natural areas into wetlands to replace those destroyed or compromised by development projects and other human activity. (Skill areas include botany, biology, ecology, engineering, hydraulics, hydrology, mathematics, statistical analysis, landscaping, horticulture, meteorology, public regulations, environmental law, written and oral communications, research, etc.)

The following statements come from a Worldwatch Institute publication, *Jobs in a Sustainable Economy*, by Michael Renner:

- "U. S. pollution control outlays of $100 billion supported or created almost 3 million jobs." (p. 23)

- "Improved efficiency is cheaper and promises more job creation than supplying energy from conventional energy sources." (p. 25)
- "If all U. S. low-income housing units were weatherized, a total of 1.4 to 1.8 million job-years might be generated." (p. 27)
- "While a shift from fossil fuels to solar energy entails job losses in the former, there are overlaps among the kinds of suppliers and skills required." (p. 29)

Environmentally related jobs have been created and will be created from environmental policy decisions, such as a shift to solar energy, for example, or to weatherization of homes to save fuels.

## C. WHAT DO YOUR STUDENTS NEED TO KNOW TO TAKE CARE OF MOTHER EARTH?

- **They need an attitude that learning is life-long; it does not stop when one leaves formal schooling.**

  The Earth is changing, the human, animal, and plant populations are increasing in some parts of the world, declining in others. Human populations, especially but not exclusively in third world countries, are being devastated by the AIDS virus. Environmental health concerns from this and other diseases that will inevitably develop bring with them new challenges in research for immunization and cures. For example, botanists are working on developing a strain of banana that is resistant to a disease that currently threatens to wipe out the economies of some South American countries whose livelihoods are totally dependent on this single export.

  Lifelong learners are necessary to help meet such challenges.

- **They need to know all their subjects because environmental challenges are interdisciplinary in nature.**

  The decline in fossil fuels will compel the search for new fuel sources. If discovered, new fuel sources will require new designs for fuel use and therefore new vehicles, new machines, new equipment to harness the new power sources. Engineering changes will call for safe production, storage, and transportation of such fuels.

  Communicators, psychologists, and educators will be needed to help people understand and cope with these shifts in lifestyle.

- **Students need to understand the big picture.**

  Everything is connected to everything else. Students should have the opportunity to learn and grow and forge opportunities to contribute their intelligence and energies on behalf of a good life for themselves and others in the world. At the same time, they should understand the responsibilities they have to take care of the home we hold in common with the penguins of the Antarctic, monkeys in the rainforests of Brazil, the spotted owl of the old growth forests in the northwestern United States.

## PROCEDURE:

A. Bring people to your classroom from the community. Bring in men and women, young and old, of all races and ethnic extractions. Ask them to demonstrate their work -- equipment, inventions, computer programs, designs for new machines, a speech they have written, notes from a court case they have argued and won or lost. Ask them to describe a typical day.

Ask them to share with students what else they have done before this job. Tell them that you wish your students to understand all that a job requires -- people skills, specific skills and information, ability to communicate, ability to report and plan, etc. Ask them to talk about their education and their training.

Invite them to share a problem with your students, something they are working on and to seek students' suggestions about how they might solve the problem.

B. If at all possible, ask if you might take your students to their worksites as well. Let them smell the smells, hear the sounds, see others working. Let them hear what they talk about, let them see how they dress, what they are reading. Let them hear the personal narratives of how people "got there," what they like about their work, what they don't like; what they have used most from their years in school.

C. Set up mentoring programs for students in areas in which they have expressed interest. It will require letters, telephone calls, logistics, permission slips, parents' and/or volunteers' assistance in getting children to and from their assignments, but it is more than worth the effort.

A mentoring program can be of many different time spans: a student visiting for a half day or a full day. A program may consist of periodic visits from the same person throughout the school year, to bring children up to date on the latest work.

D. Tell these community resource people what you want, confirm in writing, and follow up with a personal meeting to arrange details:

- Practical information
- Enthusiasm for learning
- Honesty about what's been easy and what's been hard
- What they wished they had learned in school
- How their work is important to the environment
- What a student should study to prepare for the career
- What new things they have learned and continue to learn about their job
- What other jobs they had before they came to their present position (it's important for children to understand the concept of working one's way to a job through other positions)
- Samples of their work, tools of their trade, anything the students might examine, operate, hold
- If visiting the work site, an opportunity for students to see the staff at work
- Other information that you believe would be helpful to your class

E. Local contacts: See "Suggested Environmental Career Resources" at the end of this activity.

## FURTHER STUDY:

You may want to assign your students to research the variety of environmental careers available to them. A good starting place would be two books referenced below, *The New Complete Guide to Environmental Careers* and *Environmental Career Directory*.

*The New Complete Guide to Environmental Careers* contains four sections, with the first concentrating on how to find the education and internships/volunteer opportunities that will prepare someone for an environmental career, while the other three parts focus on specific career paths: Part I - "Job Hunting in the Environmental Field"; Part II - "Planners and Communicators" (planning and environmental education); Part III "Environmental Protection" (solid waste, hazardous waste, air quality, and water quality management; and Part IV -"Natural Resource Management" (land and water conservation, fishery and wildlife management, parks and outdoor recreation, and forestry). Each major subtopic includes background preparation, case histories, issues, general salary ranges, and an overview of the major laws which apply to those employment fields.

The *Environmental Career Directory* commits more pages to job preparation, job searches, resume writing, and conducting job interviews. As such, it supports well the need for mastery of many disciplines – skills in writing, speaking, personal presentation, and other areas – that students need in practical, life-long learning and job performance. It contains a listing of corporations (name, address, telephone, and fax number), a thumbnail sketch of the company, and the names of contact persons at each. The "Advice from the Pros" section contains job backgrounds written by 17 different authors (they include such fields as wetland management, microbiology, ecology, horticulture, waste management, public gardens, industrial hygiene, etc.), allowing for a diversity of viewpoints on how to refine students' interests into specific environmental careers.

## SOURCES:

CEIP Fund. *The New Complete Guide to Environmental Careers.* Washington, D.C.: Island Press, 1993.

Morgan, Bradley and Joseph M. Palmisano, eds. *Environmental Career Directory.* Detroit, MI, Visible Ink Press, 1993.

Renner, Michael. *Jobs in a Sustainable Economy.* Worldwatch Paper 104. Washington, D.C.: Worldwatch Institute, 1991.

## ACKNOWLEDGEMENTS:

Our thanks to Mary Chadbourne for writing this activity.

# SUGGESTED ENVIRONMENTAL CAREER RESOURCES

Office of Public Affairs
BP America Research Center
4440 Warrensville Center Road
Cleveland, OH 44128
581-5600

BP America Headquarters
200 Public Square
Cleveland, OH 44114
586-4141

Public Relations
East Ohio Gas Company
1717 East 9th Street
Cleveland, OH 44114
736-6225

Richard Barton, Deputy Commissioner
Cleveland Public Power
1201 Lakeside
Cleveland, OH
664-3297

Commissioner
Division of Environmental Health
Health Department
1925 St. Clair Avenue
City of Cleveland
Cleveland, OH
664-2324

Community Affairs
Cleveland Electric Illuminating Company
55 Public Square
Cleveland, OH 44113
479-4797

Janet Abdallah
Public Information Officer
Northeast Ohio Regional Sewer District
3826 Euclid Avenue
Cleveland, OH 44115
881-6600

Jeanne Armelli
Speakers Bureau
Administrative Offices
Cleveland Metroparks
4101 Fulton Parkway
Cleveland, OH 44144
351-6300 voice mail #: 268

MetroParks Ranger Hdqtrs: 243-7860
Wildlife rehabilitation: 871-9453
Zoo: 661-6500

Joanna Bristol
Speakers Bureau
The Garden Center of Greater Cleveland
11030 East Boulevard
Cleveland, OH 44106
721-1600 extension 22

Ralph Sievert, City Forester
Division of Parks & Urban Forestry
City of Cleveland
750 East 88th St.
Cleveland, OH 44108
664-3104

Don Slogar, Manager
Greenhouse
City of Cleveland
750 E. 88th Street
Cleveland, OH 44108-4100
664-3103
(Note: The City Greenhouse asks
for a $25 donation for visits)

Sierra Club
13677 Old Pleasant Valley Road
Cleveland, OH 44130
843-7272

The following are sources of part-time, full-time and seasonal opportunities in environmental areas. They provide sample issues and listings which students can review:

***Environmental Opportunities***

A monthly listing of available positions in environmental careers. P. O. Box 969, Stowe, VT 05672

***Job Seeker***

A bi-weekly publication that of jobs and internships in environmental fields throughout the country. Route 2, Box 16, Warrens, Wisconsin 54666.

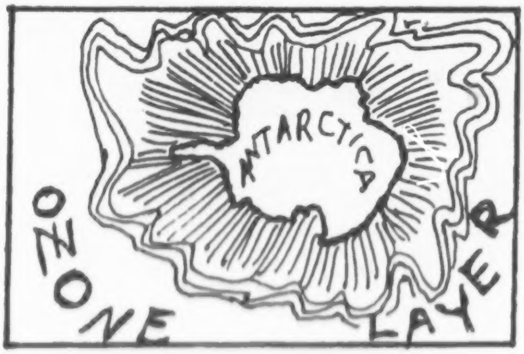
***Earth Work***

Monthly publication of environmental job opportunities throughout the country. Student Conservation Association, P. O. Box 550, Charleston, NY 03603. Telephone 603/826-4301.

# THE OZONE HOLE BLUES

**Subjects:** Music, language arts, communications, environmental science, science, history

**Format:** One or two class periods or combined class and homework assignments, independent or team assignment



**OBJECTIVE:** Students will write the lyrics and/or music for environmentally oriented songs and perform them.

**METHOD:** Students can write original music or use familiar tunes. Their lyrics can reflect specific issues in solid waste and recycling at their schools or environmental subjects generally that they choose or the teacher assigns.

**BACKGROUND:** Children are probably already very familiar with the practice of taking a familiar tune and rewriting the lyrics. Many of them will already have done so on their own or with brothers and sisters or friends just for the fun of it. Assigning them to produce a set of lyrics with a specific subject focus and message can therefore be an engaging assignment in learning about audience, rhythm, vocabulary, understatement and overstatement, and the use of art forms to make social statements.

Going the next step, having them write the original music for such songs, can open a range of opportunities: to involve students who might not otherwise be engaged by a school assignment, develop student teams -- writers and musicians -- who might not otherwise work together, give students who are interested in music (but who may not play in the school's music programs) an opportunity to show their talents, team together students who may be gifted composers but who do not read music with those who are musically talented and can write down the music that their fellow students compose so well in their heads. In short, it's an opportunity to find common ground among students who believe they have little or nothing in common. Having put together such matches in an activity that requires collaboration and cooperation, students may gain new respect for each other and for the demands of creating a finished piece of art.

Whether "borrowed" or originally composed, the music can be of any type and in any tradition: rock, rap, waltz, blues, bebop, jazz, folk, classical, etc. It may be serious or comic, value neutral or vintage "protest song" variety. The performance may be simple piano accompaniment to voice or full band or orchestra and vocals. These choices can be made by the individual teacher to suit the needs of the class and the school, working within what is logistically possible.

For example, the original song included here, "The Ozone Hole Blues," was written in response to several things, in particular to a growing concern about the hole in the Earth's protective ozone layer caused by destructive substances, particularly CFCs (chlorofluorocarbons). One result of the ozone layer damage is that humans are exposed to more ultraviolet rays, with the rates of skin cancer expected to rise in the next few years as a result. An official in the Reagan administration commented that this threat would be a boon to the economy because people would buy many more pairs of sunglasses and hats to protect themselves from the sun's rays. Hence, the song.

The teacher may assign existing tunes or have the students suggest some that would be fun to adapt. Whatever the choices, students should be encouraged to explore the content of their lyrics: a little research on water pollution, the ozone problem, solid waste, recycling, oil spills, etc., can lead to rich lyrics and fresh statements about some pressing social issues.

Finally, this activity provides an excellent opportunity to demonstrate to students the many skills and knowledge areas that contribute to a performance piece. Composing, writing the score, researching topics for lyrics, writing lyrics, orchestrating, rehearsing, publicizing, and performing. If the pieces warrant it, enterprising students might even wish to "sell" their creations through an agent, setting up a fund for the proceeds and earmarking it for recycling programs, scholarships, or other causes. This requires further research assignments for them to learn the requirements of copyrights, contracts, agents, etc.

**PROCEDURE:** The following are some options which teachers may choose from, based on the ages of their students; the talents within the class; the opportunities for performance both in class and before the student body and the public.

A. Perform an existing piece. (A sample work is attached at the end of this activity, both the lyrics and the musical score.) Have students discuss the fit of the music and the lyrics. Ask them about the content -- what do they know about the ozone layer, in this case? What harms it? What helps preserve it?

B. Assign students to write lyrics to an existing tune. Some familiar tunes and ideas for lyrics are suggested below (We have not supplied the original lyrics to the songs; provide students with them or assign them to find them out and write them down for use in class. They will help students to generate new lyrics.):

1. "On Top of Old Smokey" -- Might begin with "On top of the landfill, all covered with trash . . ." The focus is on telling a story about recycling and reducing the waste sent to landfills.

2. "This Land Is Your Land" -- Have students sing the original song; then add verses about keeping our land litter-free and conserving resources.

3. "Old McDonald Had a Farm" -- Might begin with "Old McDonald had an organic farm . . ." and then carry on with the idea that he used his land wisely, was a good steward, didn't abuse the soil, use pesticides or chemical fertilizers. Focus on sound agriculture and land-use practices.

4. "It's Not Easy being Green" -- Kermit the Frog's song. Compose lyrics about getting others to recycle, not litter, conserve energy, etc.

5. "If I Were a Rich Man" -- Might begin with, "If I were a tin can . . ." and go on to talk about recycling, the process, etc.

6. Here are some other songs with which students might be familiar and which might be fun to adapt:

    a. "Puff the Magic Dragon"

    b. "Sixteen Tons"

    c. "Imagine"

    d. "When You Wish upon a Star"

    Have the class suggest others.

C. Assign both original music and lyrics to students as individual assignments or team efforts.

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D. Perform the pieces in class and, if possible, at school events: the kick-off for the recycling program, a parents' visitation night, etc.

E. As suggested in the "Background" section, above, if students' compositions warrant it, they may wish to sell their songs commercially. Assign students to look into the requirements of copyrighting material, making a tape, being represented by an agent, setting up a school fund to receive proceeds, entering a contract.

## ACKNOWLEDGEMENTS:

Our thanks to Anne Claire Broughton and Mary Chadbourne for writing this activity.

# THE OZONE HOLE BLUES - LYRICS

Well, I woke up this mornin'
and I jumped out of bed,
There was a great big hole in the ozone
right over my head!

Well, I was getting warmer
as the sun was shining down,
I said "We've got to stop those chlorofluorocarbons
from floating around!"

Oh yeah, I've got those ozone hole blues!

Well, some countries got together,
made a treaty like they should,
but such a small cut in the CFCs
won't do us much good.

There'll be a lot more skin cancer,
politicians heard the facts,
but they said "That problem's easy --
just wear sunglasses and hats!"

Oh yeah, I've got those ozone hole blues!

Yes, the hat industry may prosper,
right across the global maps,
but the destruction of the ozone
is not a feather in our caps!

Oh yeah, I've got those ozone hole blues! Oh yeah!

-- © 1991 by Anne Claire Broughton

# THE OZONE HOLE BLUES

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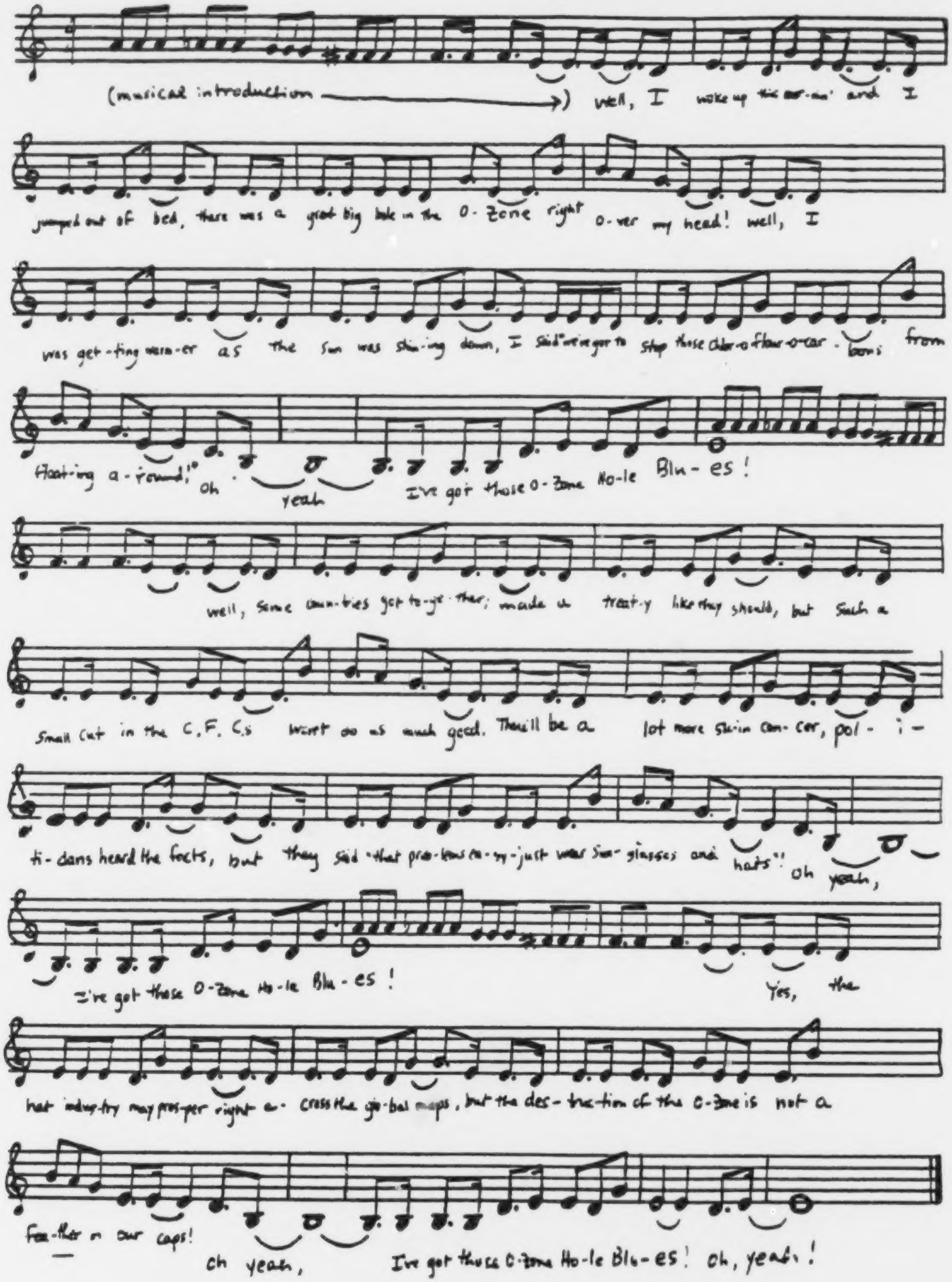
(musical introduction ——————→) well, I woke up this mor-nin' and I
jumped out of bed, there was a great big hole in the O-Zone right over my head! well, I
was get-ting warm-er as the sun was shin-ing down, I said "we've got to stop those chlor-o-fluor-o-car-bons from
floating a-round!" Oh yeah I've got those O-Zone Ho-le Blu-es!
well, Some coun-tries got to-ge-ther; made a treat-y like they should, but such a
small cut in the C.F.C.s won't do as much good. There'll be a lot more skin can-cer, pol-i-
ti-cians heard the facts, but they said "that prob-lem's ea-sy-just wear sun-glasses and hats"! Oh yeah,
I've got those O-Zone Ho-le Blu-es! Yes, the
hat indus-try may pros-per right a-cross the glo-bal maps, but the des-truc-tion of the O-Zone is not a
fea-ther in our caps! Oh yeah, I've got those O-Zone Ho-le Blu-es! Oh, yeah!

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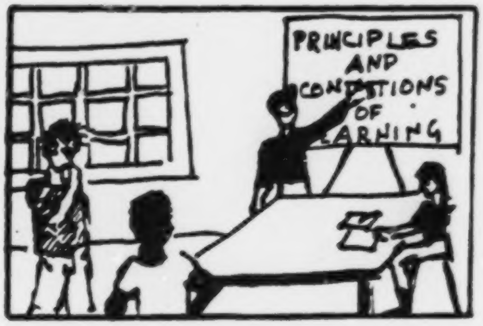
# LEARNING ABOUT LEARNING: AN ENVIRONMENTAL APPROACH

**Subjects:** Language arts, civics, psychology, history, individual investigations, special projects

**Format:** One class period, or expandable to a full year's ongoing assignment for an individual student or teams of students; specific variations by grade-level are suggested



**OBJECTIVE:** The objective is for students to (1) become familiar with a set of principles and conditions of learning, (2) analyze these principles and conditions one-by-one or as a set, and (3) interpret them one-by-one or as a set with respect to their own personal experience as a learner and as an observer of other learners.

**METHOD:** The teacher can select various ways to present the material. The complete, conventional presentation of these principles and conditions appears on pages 5 - 12 of this manual. In addition, photocopyable or ready-to-post enlarged versions of the principles and conditions appear at the end of this assignment so that teachers can use them singly as posted items, as hand-outs, as individual team assignments, etc. We have separated the summary statement of each from the explanation so that teachers may use them individually as writing or discussion pieces in which students are asked to infer the summary from the explanation or to infer an explanation from the summary.

**BACKGROUND:** Perhaps the most powerful lesson a teacher can deliver to students is not the explicit, the spoken fact of science or grammar, but the implicit, the unerring regard and respect for each student's uniqueness and potential. Students who are nurtured under such regard and respect are students who feel valued both for what they are and what they can become. Such students have every reason to learn and to stretch themselves to learn more. They are supported by their teacher's expectations and by a classroom climate that supports all of who they are and can become. From an "environmental" point of view, the processes of teaching and learning are firmly bound together by this ethic: nurture all and waste nothing. Humans are "resources" of this Earth, just as prairie grasses, the great whales, the bacteria in the gut that aid digestion, the gold reserves of Africa, the air which we breathe, the sun's light. For teachers, "wasting nothing" means that on behalf of every student we must practice a kind of "educational aikido," (to paraphrase energy-expert Amory Lovins), a balance, an art, everyday in the classroom to make school and learning an affirmation of every child.

How can that be done? In the twenty-year experience of the Institute for Environmental Education, it can be done by conducting a classroom based on the "Principles and Conditions of Learning."* (see pp. 5 - 12) These principles and conditions are what we believe are essential to practice if our *human* resources are not to be wasted. Humans are, after all, like trees, a renewable resource. The quality of our lives today was in part established by our parents and grandparents. It depended on their knowledge and use of the Earth's many parts. Now **our** knowledge and use will determine the quality of our children's lives. Therefore, we must respect and regard our stewardship of the diversity of all things, living and non-living.

**MATERIALS:** The only materials required are the attachments at the end of the activity and the full set of "Principles and Conditions of Learning," pages 5 - 12 in the front of the manual. (NOTE: The summary statements and the explanations are printed on **separate** pages in the attachments at the end of this activity to accommodate the ranges of uses in the classroom; they appear **together** only on pages 5 - 12.)

**PROCEDURE:** The teacher can use the materials in a number of ways:

A. As posted material in the classroom: the entire set of principles and conditions can be posted in their summary form or along with the explanatory material for each one.

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*** Joe Chadbourne designed the Institute's earliest programs at University School, Cleveland, OH, in 1966-67 and at Tilton School, Tilton, NH, in 1968-69. The educational philosophy guiding these programs was a practical, hands-on problem-solving approach calling for both individual and group work in an environment that encouraged experimentation and discovery rather than lecture and delivery of answers by a conventional teacher or workshop leader. While Chadbourne was Headmaster of Tilton School and running the Tilton water quality workshops, School Librarian, Winifred Talbot, discovered an article on learning theory in 1969 that exactly matched the teaching methodology used in the University and Tilton School models. Upon returning to Cleveland, Ohio, and founding the Institute, Chadbourne adopted that written version as the Institute's educational philosophy. It is excerpted from an article by Gerald J. Pine and Peter J. Horne, "For Learning in Adult Education," published in October 1969 in the periodical, *Adult Leadership*.**

1. They could be posted the first day of class and remain posted throughout the school year.
2. A teacher may wish to post only the first principle the first week of school, and then add a new principle or condition each following week until all are displayed.

B. As posted material, they can serve as the basis for:

1. Discussion with students,
2. Writing assignments,
3. Informal debates in which students agree or disagree with a given statement or explanation.

C. The "Principles and Conditions" can also be used as hand-outs to students as writing assignments in-class or at home that are aimed at helping students to understand their own learning processes, styles, and the challenge that the educational process makes to both educators and learners. (For example, students might be assigned to write about two instances of learning in their lives where they can see now that a single or several principles and conditions were operating. They would explain each case and describe how learning this way felt, perhaps comparing and contrasting it to other kinds of learning in other situations.)

D. In contrast to formal classroom education efforts, students can also be asked to assess what they have learned in other learning situations (scouting, athletics, other extra-curricular or co-curricular activities or from parents, brothers and sisters, and other relatives). Conducted as a discussion or writing exercise, ask students such questions as, "How and why did the other learning situation differ from classroom learning?" "Is there any way that classroom and other learning techniques could be mutually enhancing?"

E. A fruitful parent/teacher/student discussion can be held around any or all of these principles and conditions. Ask students to plan a time, place, and agenda for such a discussion. It should include goals and objectives for every participant.

## DISCUSSION/QUESTIONS:

A. Principle 2 is a very provocative one about which some teachers may feel discomfort. (1) Ask students about their views of it. (2) Ask them to reword it without changing the meaning.

B. Ask students whether cultural, political, racial, gender, and/or religious beliefs could be incompatible with these principles and conditions, both historically and currently. How? Why? To what effect?

C. "Knowledge is the ultimate source of power." Ask students to discuss this idea in light of (1) the principles and conditions of learning and (2) their own lifetime of learning thus far.

D. Present students with the following thesis: "The health and well being of a society is reflected in and predicted by the knowledge of its individual citizens." Discuss.

## FURTHER STUDY:

The following books are suggested for their spirit as well as their content. Any one of them would be excellent reading for teachers and high school and college students. The genres include essays, novels, poetry, autobiographies. The subjects include biology, fishing, self-sufficiency, spiritual quests, ecology, coming of age, cultural anthropology, etc.

Berry, Wendell. *The Gift of Good Land*. San Francisco: North Point Press, 1981.

Carson, Rachel. *The Sea Around Us*. New York: Oxford University Press, 1961.

____. *Silent Spring*. Boston: Houghton Mifflin, 1962.

Commoner, Barry. *The Closing Circle*. New York: Alfred A. Knopf, 1971.

Dewey, John. *Education and Experience*. New York: Collier Books, 1963.

Dillard, Annie. *Pilgrim at Tinker Creek*. New York: Bantam Books, Harper's Magazine Press, 1974.

___. *Teaching a Stone to Talk.* New York: Harper & Row, Publishers, 1983.

Doerr, Harriet. *Stones for Ibarra.* New York: Viking Press, 1984.

Dyson, Freeman. *Disturbing the Universe.* New York: Harper & Row, Publishers, 1979.

Gould, Stephen J. *The Mismeasure of Man.* New York: Norton, 1981.

Harris, Marvin. *Our Kind: Who We Are, Where We Came from, Where We Are Going.* New York: Harper & Row, 1989.

Leopold, Aldo. *A Sand County Almanac.* New York: Ballantine Books, 1966.

Maclean, Norman. *A River Runs through It.* Chicago: University of Chicago Press, 1976.

McPhee, John. *Table of Contents.* New York: Farrar, Straus and Giroux, 1985.

Maxwell, Gavin. *A Ring of Bright Water.* New York: Dutton, 1960.

Nearing, Helen and Scott. *Living the Good Life.* New York: Schocken Books, 1970.

Roethke, Theodore. *The Collected Poems of Theodore Roethke.* Garden City, NY: Anchor Press/Doubleday, 1975.

Thomas, Lewis. *Lives of a Cell.* New York: Bantam Books, The Viking Press, 1974.

___. *The Medusa and the Snail.* New York: The Viking Press, 1979.

Thoreau, Henry David. *Walden.* New York: Doric Books, 1950.

Van der Post, Laurens. *A Story Like the Wind.* New York: Harcourt, Brace, Jovanovich, Publishers, 1972.

Worster, Donald. *Nature's Economy: The Roots of Ecology.* San Francisco: Sierra Club Books, 1977.

## ACKNOWLEDGEMENTS:

Our thanks to Mary Chadbourne for writing this activity.

# Principle 1:

Learning is an experience which occurs inside the learner and is activated by the learner.

# Principle 2:

No one directly teaches anyone anything of significance.

# Principle 3:

**Learning (behavioral change) is a consequence of experience.**

# Principle 4:

# Learning is a cooperative and collaborative process.

# Principle 5:

**Learning is an evolutionary process.**

# Principle 6:

## Learning is sometimes a painful process.

# Principle 7:

**One of the richest resources for learning is the learner himself.**

# Principle 8:

The process of learning is emotional as well as intellectual.

# Principle 9:

The process of problem solving and learning is highly unique and individual.

# Condition 1:

**Learning is facilitated in an atmosphere which encourages people to be active.**

# Condition 2:

**Learning is facilitated in an atmosphere which promotes and facilitates the individual's discovery of the personal meaning of ideas.**

# Condition 3:

**Learning is facilitated in an atmosphere which emphasizes the uniquely personal and subjective nature of learning.**

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# Condition 4:

**Learning is facilitated in an atmosphere in which difference is good and desirable.**

# Condition 5:

Learning is facilitated in an atmosphere which constantly recognizes people's right to make mistakes.

# Condition 6:

**Learning is facilitated in an atmosphere which tolerates ambiguity.**

# Condition 7:

**Learning is facilitated in an atmosphere in which evaluation is a cooperative process with emphasis on self-evaluation.**

# ndition 8:

arning is facilitated in
atmosphere which
courages openness of
lf rather than
ncealment of self.

# Condition 9:

**Learning is facilitated in an atmosphere in which people are encouraged to trust in themselves as well as external sources.**

# Condition 10:

Learning is facilitated in an atmosphere in which people feel they are respected.

# Condition 11:

**Learning is facilitated in an atmosphere in which people feel they are accepted.**

# Condition 12:

## Learning is facilitated in an atmosphere which permits confrontation.

**Principle 1:**

**The process of learning is primarily controlled by the learner and not by the teacher (group leader). Changes in perception and behavior are more products of human meaning and perceiving rather than any forces exerted upon the individual. Learning is not only a function of what a teacher does to or says to or provides for a learner. More significantly, learning has to do with something which happens in the unique world of the learner. It flourishes in a situation in which teaching is seen as a facilitating process that assists people to explore and discover the personal meaning of events for them.**

**Principle 2:**

If teaching is defined as a process of directly communicating an experience or a fragment of knowledge, then it is clear that little learning occurs as a result of this process and the learning that does take place is usually inconsequential. People learn what they want to learn, they see what they want to see, and hear what they want to hear. Learning cannot be imposed. When we impose ideas on people we train them. When we create an atmosphere in which people are free to explore ideas in dialogue and through interaction with other people, we educate them. Very little learning takes place without personal involvement and meaning on the part of the learner. Unless what is being taught has personal meaning for the individual he will shut it out from his field of perception. People forget most of the content "taught" to them and retain only the content which they use in their work or content which is relevant to them personally.

## Principle 3:

People become responsible when they have really assumed responsibility, they become independent when they have experienced independent behavior, they become able when they have experienced success, they begin to feel important when someone likes them. People do not change their behavior merely because someone tells them to do so or tells them how to change. For effective learning [to take place], giving information is not enough, i.e., people become responsible and independent not from having other people tell them that they should be responsible and independent but from having experienced authentic responsibility and independence.

**Principle 4:**

**Cooperation fosters learning -- "Two heads are better than one." People enjoy functioning independently but they also enjoy functioning interdependently. The interactive process appears to "scratch and nick" people's curiosity, potential, and creativity. Cooperative approaches are enabling. Through such approaches people learn to define goals, to plan, to interact and to try group arrangements in problem solving. Paradoxically, as people invest themselves in collaborative group approaches they develop a firmer sense of their own identification. They begin to realize that they count, that they have something to give and to learn. Problems which are identified and delineated through cooperative interaction appear to challenge and to stretch people to produce creative solutions and to become more creative individuals.**

## Principle 5:

Behavioral change requires time and patience. Learning is not a revolutionary process. When quick changes in behavior are demanded we often resort to highly structured procedures through which we attempt to impose learning. Whether such learning is lasting and meaningful to the learner is doubtful. Implicit in all the principles and conditions for learning is an evolutionary model of learning. Learning situations characterized by free and open communication, confrontation, acceptance, respect, the right to make mistakes, self-revelation, cooperation and collaboration, ambiguity, shared evaluation, active and personal involvement, freedom from threat, and trust in the self are evolutionary in nature.

**Principle 6:**

Behavioral change often calls for giving up the old and comfortable ways of believing, thinking, and valuing. It is not easy to discard familiar ways of doing things and incorporate new behavior. It is often "downright" uncomfortable to share one's self openly, to put one's ideas under the microscope of the group, and to genuinely confront other people. If growth is to occur pain is often necessary. However, the pain of breaking away from the old and the comfortable is usually followed by appreciation of and pleasure in the discovery of an evolving idea or changing self.

## Principle 7:

In a day and age when so much emphasis is being placed on individual instructional media, books, and speakers as resources for learning, we tend to overlook perhaps the richest resource of all -- the learner himself. Each individual has an accumulation of experiences, ideas, feelings, and attitudes which comprise a rich vein of material for problem-solving and learning. All too often this vein is barely tapped. Situations which enable people to become open to themselves, to draw upon their personal collection of data, and to share their data in cooperative interaction with others maximize learning.

Principle 8:

Learning is affected by the total state of the individual. People are feeling beings as well as thinking beings and when their feelings and thoughts are in harmony learning is maximized. To create the optimal conditions in a group for learning to occur, people must come before purpose. Regardless of the purpose of a group, it cannot be effectively accomplished when other things get in the way. If the purpose of the group is to design and carry out some task, it will not be optimally achieved if people in the group are fighting and working against each other. If the purpose of the group is to discuss current issues and problems in a given field with reason and honesty, then it will not be achieved if people are afraid to communicate openly. Barriers to communication exist in people, and before we can conduct "official business" we need to work with the people problems that may exist in a group. It might be said that in any group, regardless of the people problems which exist, enough group intellectual capacity remains intact for members of the group to acquire information and skills. However, to maximize the acquisition and internalization of ideas it seems reasonable that the people problems would have to be dealt with first.

## Principle 9:

Each person has his own unique styles of learning and solving problems. Some personal styles of learning and problem solving are highly effective, other styles are not as effective, and still others may be ineffective. We need to assist people to define and to make explicit to themselves the approaches they ordinarily use so that they can become more effective in problem solving and learning. As people become more aware of how they learn and solve problems and become exposed to alternative models used by other people they can refine and modify their personal styles so that these can be employed more effectively.

## Condition 1:

The learning process thrives when there is less teacher (group leader) domination and more talk and more faith that people can find alternatives and solutions satisfying to themselves. Listening to people and allowing them to use the teacher (group leader) and the group as a resource and a sounding board, facilitates the active exploration of ideas and possible solutions to problems. People are not passive and reactive receptacles into which we can pour the "right" values, the "right" answers, and the "right" ways of thinking. People are active and creative beings who need the opportunity to determine goals, issues to be discussed, and the means of evaluating themselves. They learn when they feel they are a part of what is going on -- when they are personally involved. Learning is not poured into people, learning emerges from people.

## Condition 2:

. . . the teacher (group leader) rather than directing or manipulating people helps them to discover the personal meaning of ideas and events for them. He creates a situation in which people are freely able to express their needs rather than having their needs dictated to them. Learning becomes an activity in which the needs of the individual and the group are considered in deciding what issues will be explored and what the subject matter will be.

No matter how permissive or unstructured a learning activity may be, there exist implicit goals in the activity itself -- a group leader (teacher) is never goalless. Learning occurs when the goals of the leader accommodate, facilitate, and encourage the individual's discovery of personal goals and personal meaning in events. The art of helping people to change their behavior requires the development of goals which provide sufficient elbow room for people to explore and internalize behavior satisfying and growth-producing to themselves.

## Condition 3:

In such a situation [one which emphasizes the uniquely personal and subjective nature of learning], each individual has the feeling that his ideas, his feelings, his perspectives have value and significance. People need to develop an awareness that all that is to be learned is not outside or external to themselves. They develop such an awareness when they feel their own contributions and their value as people are genuinely appreciated.

**Condition 4:**

**Situations which emphasize the "one right answer," the "magical solution," or the "one good way" to act or think or to behave both narrow and limit exploration and inhibit discovery. If people are to look at themselves, at others, and at ideas openly and reasonably, then they must have the opportunity to express their opinions no matter how different they may be. This calls for an atmosphere in which different ideas can be** accepted **(but not necessarily agreed with). Differences in ideas must be accepted if differences in people are to be, too.**

## Condition 5:

Where mistakes are not permitted, then the freedom and the willingness of people to make choices are severely limited. Growth and change are facilitated when error is accepted as a natural part of the learning process. The learning process requires the challenge of new and different experiences, the trying of the unknown, and therefore necessarily must involve the making of mistakes. In order for people to learn they need the opportunity to explore new situations and ideas without being penalized or punished for mistakes which are integral to the activity of learning. The teacher (group leader) who feels and acts on the need to be always right creates a limiting and threatening condition to learning.

## Condition 6:

In a rigid and defensive atmosphere people feel they cannot take the time to look at many solutions, they feel highly uncomfortable without answers, and they feel there is more concern for "right" answers rather than good answers. The open and fearless exploration of solutions calls for time to explore many alternatives and time to proceed without feeling and pressures for immediate and forthcoming answers.

## Condition 7:

If learning is a personal process, then people need the opportunity to formulate the criteria to measure their progress. Criteria established by the teacher (group leader) are mostly artificial and irrelevant to persons in a group. Usually behavioral change and growth are measured by the degree to which people can regurgitate what others have tried to spoonfeed them. It is obvious that anyone can play the game of "giving the teacher what he wants." A more viable and meaningful evaluation occurs when people are free to examine themselves and the roles they play with other people. Self evaluation and peer evaluation enable people to really judge how much they have learned and grown, e.g., through audio and/or video tape recordings of their behavior people can see themselves in the process of learning. Such recordings provide tangible and concrete evidence of progress and provide a rich source of material to the group for learning. New insights evolve as people see themselves as they really are. For learning to occur the individual in the group needs to see himself accurately and realistically. This can be best accomplished through self and group evaluation.

## Condition 8:

Problem solving and learning require that personal feelings, attitudes, ideas, questions, and concerns be openly brought to light and examined. To the degree that an idea, a thought, a feeling, or an attitude related to the topic at hand is held back and not openly expressed--to that degree are the processes of learning and discovery inhibited. People need to feel that they can try something, fail if necessary without being humiliated, embarrassed, or diminished as persons. Openness of self occurs in an atmosphere free from psychological threat. People can invest themselves fully and openly in the collaborative and interactive process of learning when they know that no matter what they say or express, it will not result in psychological punishment or penalties.

## Condition 9:

They become less dependent upon authority when they can open up the self and when they feel that they have something to bring to the learning situation rather than the feeling that all learning means the acquisition of facts and knowledge from some external agent for use sometime in the future. People learn when they begin to see themselves as the wellsprings of ideas and alternatives to problems. Learning is facilitated when people begin to draw ideas from themselves and others rather than relying on the teacher (group leader).

## Condition 10:

In a group in which high value is placed upon the individuality of the members and upon the relationships that exist within the group, people learn that someone cares for them. A genuine expression of care on the part of the teacher (leader) and a warm emotional climate generate an atmosphere of safety in which people can explore ideas and genuinely encounter other people without any threat. Confrontations and differences of opinion become constructive forces in a group in which people experience that they are respected as persons. A safe atmosphere need not exclude personal confrontations which often are effective catalysts for learning.

## Condition 11:

People are free to change when they feel that change isn't being imposed upon them. It's paradoxical, but the more we try to change people the more resistant they become to change. A person must be before he can become. Accepting a person means that we allow him to hold his values and to be himself. When a man does not have to defend himself or his values, then he is free to take a look at himself and to change. An insistence on change contains an implicit note of rejection. In effect, we say to people -- I can't accept you as you are; you must change. People need to feel they have an option -- to change or not to change. They develop this feeling when they experience that they are accepted for who they are. When people or their values are attacked, it is natural that they will defend themselves. People who are busy defending themselves are not free to learn.

## Condition 12:

With free and open communication, with a non-threatening psychological climate, the unique self of each person is expressed. It is inevitable that in such a situation persons will confront persons, ideas will challenge ideas. Confrontations facilitate learning. They provide opportunities for people to have their ideas and themselves viewed and tested from the framework of other people or the group. No man learns in isolation from other people. His behavior changes and his ideas are refined and modified on the basis of the feedback he gets from other people. Confrontation is a proving ground which enables ideas to be synthesized, new ideas to emerge, and people to change.

# SHAPING THE LAND

**Subject:** History, social studies, civics, geography, economics, language arts, environmental science

**Format:** Flexible: teachers can adapt to in-class work or home assignments and/or research assignments, as desired

**OBJECTIVE:** To examine how other people use the land in an effort to gain perspective on our own land-use activities.

**METHOD:** Students read a case history of land use and discuss the attitudes presented. Then they examine land use in their own communities and draft a plan to improve on the existing pattern.

**BACKGROUND:** Like minerals, timber, or water, land itself is a resource. And like these other resources, land too can be wasted. Whether we cut down its forests, put roads across it, build cities on it, farm it, dump trash in it, or leave it alone, we establish a relationship with the landscape that guides our daily actions.

Yet, while our lifestyle has a considerable impact on the land, we rarely consider the mindset that guides such an interaction. Do we treat land as a commodity to be exploited to its fullest extent? Do we regard it as a limited provider that must be harvested with care? Or do we view land as being too precious in its own right to warrant significant alteration? Our response to these questions has serious ramifications. For, the way in which we choose to interact with the landscape reveals the manner in which we plan to live with it, both now and in the years to come.

One way to familiarize ourselves with the study of land use is to examine how others before us have interacted with the terrain. History serves as a bountiful repository of examples. Armed with these alternatives, students can assess the patterns of usage in their communities.

**MATERIALS:** A small assortment of materials are needed for each of the two parts of the activity.

A. PART I - LAND USE CASE HISTORY: Separate reading selections are suggested for each of the three age groups. Copies of the different books can be obtained through the local library. Finances permitting, a school may want to purchase several copies and put them on reserve at the school library. The readings are as follows:

**Grades K-3 & 4-6**: *The Lorax* by Dr. Seuss
**Grades 4-6 & 7-8**: *City* by David Macaulay
**Grades 7-9 & 9-12**: *Changes in the Land* by William Cronon (pp.36-81)

NOTE: These books are readily available through the public library. You can have copies transferred to a branch located near you simply by calling and making the request.

For each reading, a corresponding worksheet for students and an answer sheet for teachers are included at the end of this activity.

B. PART II - MAPPING YOUR COMMUNITY:

1. Copies of a topographic map or detailed street map of the neighborhood around the school (U.S. Geological Survey maps can be obtained at any good map store or from a library's collection).
2. Copies of the working map (included at the end of this activity)
3. 30-meter measuring tapes
4. Pencils

The above supplies should be given to each group of three students.

## PROCEDURE:

PART I - LAND USE CASE HISTORY: Assign students to read the appropriate book. Then ask them to answer the questions on the corresponding worksheet. Once students have completed this assignment, discuss their answers in class. The overall objective of the discussion is to pinpoint the attitudes toward the environment represented in the reading.

PART II - MAPPING YOUR COMMUNITY: Once an examination of this case history has been completed, students can then go about documenting the ways that land is used in their local communities. In order to conduct such a field study, refer to the worksheet entitled **MAPPING YOUR COMMUNITY** at the end of this activity. Return to the classroom after the mapping is complete and discuss findings.

## DISCUSSION/QUESTIONS:

PART I - LAND USE CASE HISTORY: see student worksheets and teacher answer sheets.

PART II - MAPPING YOUR COMMUNITY: see the **MAPPING YOUR COMMUNITY** reference sheet.

**VARIATIONS:** Teachers working with younger students may want to conduct the mapping exercise on the land immediately surrounding the school. Its familiarity will make the mapping exercise fun and manageable.

## FURTHER STUDY:

A. Assign students to read *Encounters with the Archdruid* by John McPhee and discuss the differing views on land use presented by environmentalist David Brower and the different people with whom he travels.

B. Assign another group of students to read Aldo Leopold's essay on the land ethic contained at the end of his book entitled *A Sand County Almanac* and report findings to the class.

C. Ask older students (grades 9-12) to investigate zoning in the community. How is it zoned? How is zoning accomplished? Who does it? Ask that they report their findings to the class.

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## ACKNOWLEDGEMENTS:

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## MAPPING WORKSHEET

Scale ____________

## STUDENT WORKSHEET - *THE LORAX*

QUESTIONS:

A. Why does the Once-ler cut down the Truffula trees?

B. Why does he build a factory?

C. What does he use the Super Axe Hacker for?

D. Why doesn't he listen to the Lorax?

E. What happens to the Bar-ba-loots?

F. What happens to the Once-ler's business when the last Truffula tree is cut down?

G. What did the landscape look like before the Once-ler began making "thneeds"? What does it look like after the last Truffula tree is cut down? How has it changed?

H. How might the Once-ler have prevented these changes?

I. Name some "thneeds" found in our society, things that we want but don't really need?

J. What does the Lorax mean by the word UNLESS inscribed on the pile of rocks? How does the message of the Lorax apply to our community? The whole Earth?

## TEACHER ANSWER SHEET - *THE LORAX*

SUGGESTED ANSWERS:

A. The Once-ler cuts down the Truffula trees to use their silk tufts to make thneeds.

B. The Once-ler builds a factory in order to increase his production of thneeds.

C. The Once-ler uses the Super Axe Hacker to cut down four trees at once instead of just one. This allows him to make thneeds faster than before.

D. The Once-ler doesn't listen to the Lorax because he is only interested in making money.

E. The Once-ler cuts down so many of the Truffula trees that there is no longer enough Truffula fruit to feed all the Brown Bar-ba-loots. As a result, these creatures are forced to leave.

F. When the last Truffula tree is cut down, the Once-ler's business grinds to a halt. With all the Truffula trees gone, there are no more silk tufts available to make into thneeds, so the Once-ler is forced to close his factory.

G. The beautiful landscape filled with an abundance of different kinds of plant and animal life is now completely destroyed. Filthy smoke chokes the air, pollution soils the river, and the landscape itself is completely barren.

H. The Once-ler might have minimized these changes to the environment by limiting the production of his thneeds, re-planting the Truffula trees as he cut them down, and installing special pollution control equipment on his factory.

I. Some examples of thneeds that we want but don't really need include: home video games, pre-packaged microwave cuisine, and plastic action figures.

J. When the Lorax is forced to abandon his home because the land has become so polluted, he leaves behind a small monument as a reminder that this destruction didn't have to happen. If people had refused to buy thneeds or if the Once-ler had conducted his operation in a less harmful way, the various plants and animals might have continued to flourish.

Unrelenting industrial activity that pays no heed to its effects on the environment will eventually ruin the environment **unless** we plan ahead and work to minimize the harm.

## STUDENT WORKSHEET - *CITY*

QUESTIONS:

A. What is the greatest fear of the planners of the city of Verbonia? Why?

B. How do the planners of the city ensure that the demands of its future residents will not outstrip the resources available to sustain them?

C. In what kind of pattern is the city designed?

D. Does this pattern conform to the contours of the land or is it imposed upon the terrain?

E. What are the primary building materials for the city and where do they come from?

F. Where does the city get its water?

G. Where do the sewers discharge their contents?

H. What fuel source is used to heat the houses in the winter?

I. When the city builds a new set of thermae (baths), how do they get the additional water needed to fill them?

J. How long does it take to construct the city, from drafting the original plans to completing the amphitheater and theater?

K. What are some of the changes that take place as the population of the city grows?

L. What measures do the city officials take to protect the city from the cold winds that blow down the Po Valley?

M. How many years does it take for the city to reach its intended capacity?

N. What aspects of the natural landscape have made such a concentration of people possible?

O. How does the city transform the land?

## TEACHER ANSWER SHEET - *CITY*

SUGGESTED ANSWERS:

A. The greatest fear of the planners of the city of Verbonia is overpopulation. If the city grows to a size that is greater than what it was designed to hold, the demands of the citizens will begin to strain public utilities such as water lines, sewer lines, and roads. This will lower the quality of life for all residents and may eventually lead to unhealthy living conditions. In addition, overpopulation will begin to deplete the natural resources such as firewood and farmland that sustain the city's residents.

B. The planners of the city ensure that future residents will not outstrip the resources available to sustain them by physically limiting the size to which the city can grow.

C. The city is planned or designed like a grid or chessboard with main roads running north-south and east-west.

D. This pattern is imposed upon the terrain.

E. The primary building materials for the city include stone, clay, mortar, and wood. The stone is cut from a quarry owned by the government. The clay is dug out of large pits near Arretium. The mortar is composed of sand, lime, and water, each of which was probably acquired locally. The wood comes from a forest at the foot of the Apennine mountains to the south.

F. The city gets its water first from wells inside the city walls and later from an aqueduct that transports it from mountain lakes to the south.

G. The sewers discharge their contents into the Po River.

H. The fuel source used to heat the houses is wood.

I. The additional water required by the new thermae is obtained by building a second aqueduct on top of the first.

J. It takes 100 years to construct the city, from the drafting of the original plans to the completion of the amphitheater and theater.

K. As the population of the city grows, many landlords begin to replace their small apartment buildings with larger apartment blocks that can accommodate more people. Likewise, old thermae, markets, and temples are torn down and replaced with larger structures.

L. City officials work to protect the city from the cold winds that blow down the Po Valley by restricting the construction of the first large apartment blocks to the northern and western sides of the city.

M. It takes 125 years from its founding for the city to reach its intended capacity.

N. The concentration of people is made possible by the abundance of farmland just outside the city walls as well as the reserves of water and firewood in the local region.

O. The city transforms the land by altering its surface and consuming its resources. Only careful planning by the city's original architects has prevented these human uses from overwhelming the land's ability to sustain them.

## STUDENT WORKSHEET - *CHANGES IN THE LAND*

QUESTIONS:

A. How did the Indians in New England exploit the seasonal diversity of their environment?

B. Why did some groups of Indians engage in agriculture while others did not?

C. What impact did agriculture have on Indian populations?

D. How did the Native American style of agriculture differ from that of the European colonists?

E. What aspects of the Native American lifestyle were responsible for the relatively low impact of these people on the land?

F. In what ways did the Indians alter their surroundings?

G. How did the colonists justify their conquest of New England?

H. How were Indian place names connected to the land?

I. When the Indians sold land to the colonists, what did they think they were selling?

J. What beliefs characterized the Indian and European notions of ownership?

K. To what extent does our modern-day system of land use resemble that of the early colonists?

## TEACHER ANSWER SHEET - *CHANGES IN THE LAND*

SUGGESTED ANSWERS:

A. Through their mobility, Indians in New England synchronized food-gathering with the seasonal diversity of their environment. As different sources of food came into season, Indians re-located in order to harvest at the peak of abundance.

B. For the most part, Indians in Southern New England engaged in agriculture while their Northern counterparts did not because of the differing climatic conditions. In the northern regions, the growing season was too short to provide anything more than a tenuous existence based on farming.

C. Because plant foodstuffs could be stored more easily than animal ones, farming worked to smooth out the seasonal fluctuation in nourishment, allowing agricultural villages to support larger populations. This phenomenon is substantiated by the fact that Indian populations in Southern New England were as much as seven times greater than those to the north.

D. The agricultural practices of Native Americans differed from those of the European colonists in that they grew many different crops together on the same plot of land. This resulted in high yields per acre, while at the same time discouraging weeds and maintaining the soil moisture. In contrast, European colonists grew crops separately from one another.

E. The low density and mobility of the Indians were largely responsible for their low impact on the land.

F. Indians altered their surroundings through their agricultural activities, their copious consumption of firewood, and their yearly burnings of the forest undergrowth.

G. The colonists justified their conquest of New England on the grounds that the Native Americans were wasting the resources of the land. In order to claim ownership to a piece of property, the colonists felt that one had to bound it and "improve" it through annual cultivation.

H. Indian place names were tied to the land through their identification of the resources that a given area provided. For example, Indians referred to a place in Maine as Abessah, or the "clam bake place." Azoiquoneset in Narragansett Bay was the "small island where we get pitch."

I. When Indians sold land to the colonists, they thought they were selling only the right to use the **resources** of the land (or so-called usufruct rights). Colonists, however, felt that such sales involved the **land itself**.

J. Indians felt that an individual owned that which he made with his own hands. Items were owned because they were useful. If they were no longer so, they could be easily given away. In addition, the mobility of the Indian communities discouraged the large-scale accumulation of possessions. Property rights took place on a community level. If a village established its right to a specific area, it enjoyed the privilege of utilizing the various natural resources that the area had to offer. In contrast, the colonists viewed land as a commodity that could be bought and sold. The widespread use of money enabled individuals to convert natural products into capital that could be stored without fear of spoilage. Such a system encouraged colonists to extract resources far beyond their immediate needs.

K. Our modern-day system of land use is virtually identical to that of the early colonists.

## MAPPING YOUR COMMUNITY
### (Teacher Reference Sheet)

Grades K- 6

### STEP 1 - PREPARING YOUR MAP

A. Begin by asking students,"What is a map?" Make sure they understand that a map is a scalar representation of the real landscape that helps us to find our way around.

B. Draw an outline of the land immediately surrounding the school on the blackboard. Make sure to mark the various features such as roads and streams that define the boundaries of the area.

C. Provide each student with a copy of the dotted working map included at the end of this activity

D. Copy the blackboard drawing onto the individual maps.

### STEP 2 - MEASURING YOUR PACE

When students are outside, they will need a quick way to measure distances. Therefore, perform the following procedure in order to determine pace (Note: a pace can be either a single step or a pair of steps; teachers should decide with students at the outset what type of pace to use):

A. Measure out a straight path 100 meters long using the 30-meter tape.

B. Each student should then pace the distance using his or her normal walking stride and count the number of paces required to reach the end. Students will then use their individual pace counts to measure distances around the school.

C. Tell students to keep their pace as even and as straight as possible when using this technique.

### STEP 3 - MAPPING THE NEIGHBORHOOD

A. Ask the students to begin the mapping exercise by orienting themselves outside. Ask them to determine where the various streets and other boundaries are located around them and orient maps accordingly.

B. Then assign students to identify other major landmarks and measure the distance from each of these features to the next. Make sure to draw the various landmarks on their individual maps and record all the measurements.

## STEP 4 - DRAWING THE MAP TO SCALE

A. Back in the classroom, introduce the students to the concept of scale. Explain to them that maps show where various landmarks are in relation to each other. If the proportion of the objects on the map is not the same as the proportion of the landmarks outside, then we will probably get lost.

B. Ask students to use the measurements made outside to determine the scale to use for the maps. If the distance from the school building to the playground fence is 100 meters and the distance from the swing set to the street is 200 meters, then students could make the first distance ten line segments long on their maps and the second distance twenty line segments long. In this case, one line segment would represent 10 meters. Thus, the scale of the map would be 1:10. Make sure that students choose a scale that is large enough so that the map can be read clearly but is small enough so that the entire area fits on the sheet of paper.

C. Now, assign students to re-draw the maps on a fresh sheet of dotted paper using the newly-determined scale.

## MAPPING YOUR COMMUNITY
### (Teacher Reference Sheet)

Grades 7 - 12

The objective of this part of the activity is for students to apply what has been learned in the case history to the community. As students proceed with the field study, they should consider the manner in which their community is laid out. What is located where? and why?

### STEP 1 - PREPARING YOUR MAP

A. Divide students into groups of three.

B. Provide each group with a copy of the topographic map for the neighborhood that they are going to be studying (see MATERIALS section at the beginning of the activity for information on how to obtain maps).

C. Ask them to mark north, south, east, and west on their dotted working maps.

D. Divide the neighborhood up into blocks. Each block should be bounded on all sides, whether by roads or streams or other distinct changes in land use.

E. Assign one block to each group of students.

F. Assign them to sketch the streets and other features that define the block in pencil on the working map. This will help them to orient themselves in the field. Once students begin the actual measuring of their block, they can re-draw the streets and other boundaries.

G. Ask students to read the key on the topographic map and determine the scale. They should use the scale to determine the approximate dimensions of the block. Then, ask them to figure out what scale to use on the working maps. Once the scale has been determined, it should be entered in the key on the working map.

### STEP 2 - MEASURING YOUR PACE

When students are in the field, they will need a quick way to measure distances. Therefore, ask students to perform the following steps in order to measure pace.

(Note: a pace can be either a single step or a pair of steps; teachers should decide with students at the outset what type of pace to use.)

A. Ask students to measure out a straight path 100 meters long using the 30-meter tape.

B. Each student should then pace the distance several times using his or her normal walking stride and count the number of paces required to reach the end. If teachers want to, they can designate one student in each group as the "pacer" and have this individual perform all distance measurements in the field.

C. Once each student has paced the distance several times, he or she should take an average of the different pacings and record this figure. Students will then use their individual averages when pacing distances out in the field.

D. Tell students to keep their pace as even as possible when using this technique in the field.

## STEP 3 - CONDUCTING YOUR FIELD STUDY

A. Ask students to begin the field study by orienting themselves. They should determine where the various streets and other boundaries are located around them and orient their maps accordingly.

B. Measure the distance from one type of land use to the next within your block. Each portion of land is known as a parcel.

C. Draw the different parcels on your map.

D. Categorize the different parcels by land use type and mark them using the abbreviations below (RS for residential areas, C for commercial areas, and so on).

Types of Land Use:

- **residential (RS)** - houses, apartments, condominiums
- **commercial (C)** - stores, offices
- **institutional (IS)** - schools, hospitals
- **industrial (ID)** - factories
- **paved (P)** - streets, parking lots, playgrounds
- **rights of way (RW)** - railroad tracks, overhead power lines
- **open space (O)** - parks, ballfields, cemeteries
- **abandoned (A)** - empty lots
- **other** ________________ ( ) - ______________________

## STEP 4 - ANALYZING YOUR DATA

Back in the classroom, assign each of the groups to calculate the areas (in square meters) of the different parcels found in the survey blocks. Then, as a class, add together the square meters of land devoted to each type of land use in the neighborhood. Once this information has been assembled, ask the students the following questions:

A. How many different land uses are there in your community?

B. Which land uses take up the largest space?

C. Are certain uses concentrated in certain areas? If yes, why?

D. What are some of the benefits of the present land-use relationship in your community?

E. What are some of the problems with these uses in your community? Do the different land uses conflict with each other? Are they appropriate for the terrain? Is land used efficiently? Is the area a safe place to live? Is the area a healthy place to live?

F. How would you re-design your community to resolve some of these problems? How will these changes make the area a better place in which to live and work?

# GLOSSARY

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**Aluminum:** a silvery non-ferrous metal found in bauxite; it is used in making hard, light, corrosion-resistant materials such as beverage containers

**Aquifer:** a porous layer of underground rock that holds water

**Biodegradable:** material which can be broken down into simple chemical compounds by bacterial, fungal, and freely occurring biochemical actions

**Blackwater:** wastewater from homes that contains human wastes

**Bottom Ash:** the unburnable ash residue remaining in an incinerator or energy recovery facility after the burnables have been incinerated

**Btu:** stands for "British thermal unit," the amount of heat energy required to raise the temperature of a pound of water by 1° F

**Buying in bulk:** the purchasing practice of buying large amounts of products at one time to avoid excess packaging and transportation costs

**calorie:** the amount of heat energy required to raise the temperature of one gram of water by 1° C. (Compare "Calorie" and "Btu.")

**Calorie:** the amount of heat energy required to raise the temperature of one thousand grams (1 kilogram) of water by 1° C. (Compare "calorie" and "Btu.")

**CERCLA:** stands for "Comprehensive Environmental Response, Compensation, and Liability Act," also known as the Superfund Act. provides funding for emergency cleanup for spills and for some hazardous waste sites

**Commercial waste:** waste that comes from offices, restaurants, small businesses, etc. that are not "residential" or "industrial" wastes

**Compost:** material resulting from the natural breaking down of organic material by bacteria, fungi, and other organisms; compost is a product used to enrichen soil

**Composting:** the process of breaking down organic material by natural means -- aerobic bacteria, fungi, and mechanical means

**Conservation:** the conscious practice of using resources, both natural and manufactured, repeatedly to minimize their loss.

**Consumer:** someone who uses or buys resources, natural or manufactured

**Contamination:** (of recyclable materials) the mixing of materials which interfere with the clean processing of recyclables, i.e., contamination of office paper occurs when food, carbon paper, or metal cans are mixed with it

**Cullet:** the broken pieces of glass that are melted and formed into new products

**Cycle:** to circle, return, or occur again

**Disposable:** an item that is designed for a one-time use; disposable items such as aseptic juice glasses, baby diapers, and styrofoam packaging and food trays are so-called "convenience" items that are normally not reused

**Disposal:** the discharge, deposit, injection, dumping, incineration, leaking or placing of any waste into or on any land, air, or water medium

**Environment:** all of the organic and inorganic components surrounding us, as well as the events, conditions, and processes of their interactions

**Garbage:** any material considered nonrecyclable

**Hauling Fee:** the fee charged by a garbage or recyclables hauler to transport material from one point to another

**Hazardous Waste:** wastes which are poisonous, explosive, corrosive of metal or skin, toxic, disease-causing, radioactive, or otherwise dangerous

**Household Hazardous Waste:** wastes found in homes that are poisonous, explosive, toxic, corrosive of metal or skin, disease-causing, radioactive, or otherwise dangerous

**Humus:** the rich soil resulting from composting

**Incineration (solid waste):** reducing the volume of solid wastes by use of an enclosed controlled flame combustion

**Incinerator:** a furnace, boiler, kiln, or other device for burning wastes under controlled conditions

**Inorganic:** composed of matter that is not and was not living; generally composed of chemical compounds not based on the element carbon

**Landfill:** a large, outdoor area for waste disposal; in sanitary landfills, layers of soil and waste are alternated

**Leachate:** liquid that is formed when water percolates through the soil and waste in a landfill, leaching a variety of suspended and dissolved materials from the waste

**Litter:** solid waste that collects along streets and in buildings, usually due to careless disposal practices or willful improper discarding

**Mass-burn Facility:** an incinerator that burns solid waste without separating recyclables, non-burnables, or any other materials

**Methane:** a colorless, odorless, flammable gaseous hydrocarbon present in natural gas and formed by the decomposition of organic matter -- $CH_4$

**Municipal Solid Waste:** solid waste produced by residential, commercial, and institutional generators within a community; generally does not include industrial waste

**Municipal wastewater:** all of the combined wastewater in a municipal area -- commercial, industrial, residential, etc.

**Natural Resource:** material or energy obtained from the environment that is not produced by humans but is used to meet human needs

**Nonpoint source pollution:** undefined sources of water pollution, such as street runoff, erosion from construction and agricultural areas, etc.

**Nonrenewable Resources:** resources not capable of being naturally restored or replenished, or that are replaced more slowly than they are used, such as oil, iron ore, uranium

**Organic:** composed of living or once-living matter; composed of chemical compounds based on the element carbon

**Packaging:** the materials used to wrap, contain, and protect products

**Point source pollution:** water pollution sources that may be traced to a specific source, such as a sewer line or a discharge pipe of an industrial facility

**Pollute:** to contaminate; to make impure

**Pollution prevention:** the reduction, reuse, and recycling of materials to preclude them from the waste stream entirely

**Post-consumer Waste:** waste that is generated from materials previously used by consumers, such as paper that has been used by consumers and can be reused or recycled again

**Pre-consumer Waste:** waste that is generated during the manufacturing process and does not involve consumers; i.e., paper trimmings from a paper mill

**Processing:** the procedures used to change the initial form of materials

**Raw Materials:** substances still in their natural, unprocessed state

**RCRA:** stands for "Resource Conservation and Recovery Act," a federal law requiring that states develop solid waste management plans (passed in 1976); established as a "cradle-to-grave" tracking and liability system for hazardous waste

**Recyclables:** waste materials capable of being reprocessed and used in the manufacture of new products

**Recycle:** to separate a material from waste and process it again into another form; i.e., newspapers recycled into newspaper or cardboard

**Reduction:** the process of decreasing the amount of waste generated

**Renewable Resources:** capable of being naturally restored or replenished

**Reuse:** to use again

**Sanitary Landfill:** a waste disposal site with an impermeable lower liner to keep leachate from draining into the groundwater, a leachate collection system, gravel layers permitting the control of methane, and other features; waste is spread in layers, compacted, and covered at the end of each operating day

**Solid Waste:** non-liquid materials which are considered worthless and are discarded

**Source reduction:** the most important means for reducing solid waste, source reduction solves the waste problem where it is first generated, often by redesigning products or solving process and manufacturing problems that generate waste

**Stewardship:** taking responsibility and caring for an entity such as a plot of land

**Sustainable:** the ability to support, endure, or keep up economically without depleting or damaging resources

**Tipping Fee:** the fee charged at a landfill to dump waste

**Toxic Waste:** substances containing poison and posing a substantial threat to human health and/or the environment

**Transfer station:** an area where waste is collected and stored temporarily or separated for reprocessing or for bulk hauling to another location

**Trash:** a term some use interchangeably with "garbage"

**Waste:** anything that is unwanted and is discarded

**Waste exchange:** a system where one person's waste becomes another's resource

**Waste stream:** the total waste produced by a community or society

**White goods:** household appliance waste (stoves, refrigerators, freezers, etc.)

**Yard waste:** organic matter from mowing, trimming, pruning, weeding, etc.